Annals
of the
Missouri Botanical Garden

Volume XLII

1955

With 34 plates, 27 figures, and 60 maps

Published quarterly at Galesburg, Illinois, by the Board of Trustees of the Missouri Botanical Garden, St. Louis, Mo.

Entered as second-class matter at the post-office at Galesburg, Illinois, under the Act of March 3, 1879.

MISSOURI BOTANICAL
RECEIVED
JUN 5 - 1956
GARDEN LIBRARY

$10.00

MISSOURI BOTANICAL
GARDEN LIBRARY

Annals

of the

Missouri Botanical Garden

A Quarterly Journal containing Scientific Contributions from the Missouri Botanical Garden and the Henry Shaw School of Botany of Washington University in affiliation with the Missouri Botanical Garden.

Information

The ANNALS OF THE MISSOURI BOTANICAL GARDEN appears four times during the calendar year: February, May, September, and November. Four numbers constitute a volume.

Subscription Price ....$10.00 per volume
Single Numbers .... 2.50 each

Contents of previous issues of the ANNALS OF THE MISSOURI BOTANICAL GARDEN are listed in the Agricultural Index, published by the H. W. Wilson Company.

TABLE OF CONTENTS

		PAGE
Selaginella rupestris and Its Allies	Rolla M. Tryon	1– 99
A New *Pellaea* from South Africa	Alice F. Tryon	101–102
Studies on Asiatic Relatives of Maize	Nalini Nirodi	103–130
Lichenological Notes on the Flora of the Antarctic Continent and the Subantarctic Islands. I–IV	Carroll W. Dodge and Emanuel D. Rudolph	131–149
Three New Annonaceae from Panama	Robert E. Fries	151–152
The Botanical Catalogues of Auguste de St. Hilaire	John D. Dwyer	153–170
Comparison of Juniper Populations on an Ozark Glade and Old Fields	Marion Trufant Hall	171–194
Tassel Modifications in *Zea Mays*	Norton H. Nickerson and Ernest E. Dale	195–212
A New Species of *Doryopteris* from Surinam	Karl U. Kramer and Rolla M. Tryon, Jr.	213–214
A Revision of the Genus *Celastrus*	Ding Hou	215–302
The Food of a Hindu Village of North India (Reprinted from Bulletin No. 2, Bureau Statistics and Economic Research, United Provinces, Allahabad, 1937)	Charlotte Viall Wiser, Ph.B., M.Sc.	303–412
General Index to Volume XLII		413–418

MISSOURI BOTANICAL GARDEN

STAFF

Emeritus Director
George T. Moore

Director
Edgar Anderson

Assistant Director
Hugh C. Cutler

Carroll W. Dodge,
Mycologist

Robert E. Woodson, Jr.,
Senior Taxonomist

Henry N. Andrews,
Paleobotanist

Rolla M. Tryon,
Assistant Curator of the Herbarium

Hugh C. Cutler,
Curator Museum of Economic Plants

George B. Van Schaack,
Acting Curator of Herbarium

Julian A. Steyermark,
Honorary Research Associate

Frederick G. Meyer,
Dendrologist

Alice F. Tryon,
Research Associate

John D. Dwyer,
Research Associate

Nell C. Horner,
Librarian and Editor of Publications

BOARD OF TRUSTEES

President
John S. Lehmann

Vice-President
Daniel K. Catlin

Second Vice-President
Eugene Pettus

Leicester B. Faust
Dudley French
Henry Hitchcock
Richard J. Lockwood
Henry B. Pflager
A. Wessel Shapleigh
Rorert Brookings Smith

EX-OFFICIO MEMBERS

Arthur C. Lichtenberger,
Bishop of the Diocese of Missouri

James F. Morrell,
President of the Board of Education of St. Louis

Stratford Lee Morton,
President of the Academy of Science of St. Louis

Ethan A. H. Shepley,
Chancellor of Washington University

Raymond R. Tucker,
Mayor of the City of St. Louis

Hugh C. Cutler, *Secretary*

Volume XLII Number 1

Annals
of the
Missouri Botanical Garden

FEBRUARY, 1955

Selaginella rupestris and Its Allies . . . . . Rolla M. Tryon 1– 99

A New *Pellaea* from South Africa . . . . Alice F. Tryon 101–102

PUBLISHED QUARTERLY AT GALESBURG, ILLINOIS
BY THE BOARD OF TRUSTEES OF THE MISSOURI BOTANICAL GARDEN,
ST. LOUIS, MISSOURI.

Entered as second-class matter at the post-office at Galesburg, Illinois,
under the Act of March 3, 1879.

Annals
of the
Missouri Botanical Garden

A Quarterly Journal containing Scientific Contributions from the Missouri Botanical Garden and the Henry Shaw School of Botany of Washington University in affiliation with the Missouri Botanical Garden.

Information

The Annals of the Missouri Botanical Garden appears four times during the calendar year: February, May, September, and November. Four numbers constitute a volume.

Subscription Price	$10.00 per volume
Single Numbers	2.50 each

Contents of previous issues of the Annals of the Missouri Botanical Garden are listed in the Agricultural Index, published by the H. W. Wilson Company.

Annals
of the
Missouri Botanical Garden

Vol. 42 FEBRUARY, 1955 No. 1

SELAGINELLA RUPESTRIS AND ITS ALLIES*

ROLLA M. TRYON, JR.

These are small plants, hardly exceeding a few inches in height, yet they are a striking part of the vegetation of the semi-arid and subalpine regions of western North America, covering barren soil and festooning rock ledges. The forty-three species included in this study comprise the section *Tetragonostachys* of subgenus *Selaginella.* Thirty-two species occur in America, eight in Africa and Madagascar, and the remainder in Asia. Superficially they appear similar and nondescript but under magnification they reveal structures of beauty in design and symmetry which amply reward the student who takes more than a casual interest in them.

Selaginella rupestris and its allies occupy a unique place in xeric ecology for they are vascular plants adapted to being completely desiccated and reviving a few hours after moisture becomes available. Study of their physiological response to arid conditions would be of interest. In a number of ways the group offers data of value in geographic and evolutionary studies. *S. rupestris* is of particular cytological and geographic significance because it has both sexual and apogamous races, the latter occupying a much larger territory than the former. In this species, as well as the others, details of the life-cycle, especially the means of fertilization and of dispersal, are poorly understood. Aside from botanical collectors and browsing by deer in lean seasons, they are relatively unaffected by animals or man and the habitats which most of them occupy are relatively little affected by fire, lumbering, grazing or cultivation. Studies of the group may be of comparative value in relation to species in which the activities of man have played a critical role.

The principal effort in the present study has been directed toward a definition of the species and groups of species within a coherent framework of characters, to place the nomenclature on a firm foundation through reference to holotype material and to provide keys and illustrations to facilitate accurate identification. It is not to be expected that the keys and descriptions can be used by a student of the vascular plants without some introductory study of a few species, and indeed this

*Issued March 24, 1955.

is true of most genera. One can not successfully divorce the use of a monograph from specimens and it is not my intention that this treatment be wholly independent of such material.

The Present Classification

The taxonomy of the *Selaginella rupestris* group is beset with a number of difficulties which must be recognized and resolved before an adequate classification can be developed. The first, and perhaps most important, is the relative plasticity of the characters, not only of the vegetative parts, but of the strobili, sporophylls and spores as well. This does not mean that taxonomically useful characters do not exist but that considerable caution must be used in choosing those of specific value.

Relatively few species possess distinctive traits; rather most of them must be defined in terms of a particular combination of characters. There is evidence that there has been a great deal of parallel development in the group and that the potential variations of different structures have been realized many times. This situation has made it troublesome to find the morphological coherence of a species and the differentiating characters. Another difficulty is the very numerous characters that present themselves for consideration. In many groups, students probably feel the characters are too few and wish for more but a superabundance of them can be equally trying. The inadequate nature of most herbarium specimens has been a source of confusion for nearly all of the early collections and many contemporary ones are fragmentary. Complete mats of some fifteen species were collected in the field and notes were made on local variations of habit and habitat. With the information obtained from these studies, it was possible to understand the relation of herbarium fragments to the living plants. The minute nature of the characters has undoubtedly resulted in many of them being overlooked or misinterpreted. For example, the deciduous setae of *S. eremophila* were not detected until many years after the species was described. A relatively high magnification is needed to see the structures accurately. For general observation of the leaves and sporophylls 30 diameters is recommended, 40 diameters for the smaller details.

Inasmuch as the species must largely be defined in terms of combinations of characters rather than distinctive ones, a set of specific characters for each species does not exist by itself but only in relation to other species. One set of characters may distinguish a species from its close relatives, additional ones, or another set, may distinguish it from less closely related species. It is obvious, therefore, that before a species can be worked out, the groups of species must be defined to establish the circle within which character comparisons will be made. The following method was used to form a basis for grouping the species into natural units.

Some twenty-five presumed species of which complete material was available early in the study were scored for about thirty characters. These included some from all parts of the plant. Their value was not known although only qualitative ones were used. Each species was compared with the others for the number of

characters in common. Those that showed definite affinities with each other were grouped together. An analysis was then made for characters which would distinguish between the groups. After a certain amount of modification and rearrangement, the series and their characters were established. Such a method has a number of limitations that might make the results obtained inaccurate but when used with discretion it undoubtedly has value. The final test of the classification was the integration of some fifteen species not originally included. These took natural places within the system in regard to their geography, morphology and phylogeny.

Although many characters had been used by previous authors for the definition of species these were at first disregarded to remove all prejudice as to their possible value. The numerous available characters were reduced to a manageable number in two ways. It was assumed that lineal measurements should be avoided, if at all possible; that qualitative differences should be used for the primary characters of species. Quantitative characters of real value could be used as expressed by ratios. Structures that were variable on individual stems and within individual mats would not be reliable for taxonomic use and many characters were rejected for this reason. When the number of possibly useful characters was reduced to convenient proportions, several species were chosen to be analyzed for the characters of specific value. These were species such as S. *cinerascens*, S. *Bigelovii*, S. *oregana* and S. *tortipila* of which I had ample material and which have a distinctive morphology, a compact and natural range and a rather defined ecology. Each was examined to determine the structures that were sufficiently stable to be used as specific characters. The species were then compared with each other in terms of this final set of characters and it was found that the entire set was usable to express species differences. Such characters were then used to define the species within each series. Most of the species thus derived were found to have the following attributes: a set of sufficiently stable characters so that the "population" showed morphological cohesion; complete morphological distinction from other species; a degree of morphological cohesion and distinction that is qualitatively and quantitatively comparable to other related species; a natural geographic distribution, allopatric or largely so from related species; and a definite local ecology although this might be rather broad within the whole range. These characteristics were used as criteria for determining the category in difficult and perplexing cases. The "good" species of the section, therefore, defined themselves, their attributes were determined and the other species were defined comparatively in similar terms. Subspecific categories were defined in relation to the species.

The category subspecies is used in S. *arenicola* where the major variants have not completely developed the properties of species. The variety is used in three species but only one of these may be considered a proper example of the use of that category. That is in S. *mutica* where the two variants, although definite, have the characteristics of species poorly developed. In the case of S. *Wightii* the two varieties are recognized largely for practical reasons, the material available being

insufficient to establish the proper category. In S. *densa* a most interesting but quite unsatisfactory taxonomic condition exists. The three variants are quite distinct morphologically and geographically over large areas in the northern part of the range of the species. Here they would certainly rank as subspecies and perhaps even as species although the characters that separate them are not quite as well developed as in other species in the series. But the varieties all grow in the large central portion of the range where they exhibit such complete intergradation in characters that only one highly variable species could be recognized. I have chosen to use the category variety for them, placing perhaps a bit more emphasis upon their intergradation than upon their distinctiveness.

The species descriptions have all been taken directly from the keys and are uniform only within each series. All of the characters mentioned in the species key are included in each description. Although this is a departure from the usual procedure, it is necessary in order to emphasize the set of characters important within an evolutionary line. A number of characters used in this treatment are peculiar to the genus or at least not commonly used in vascular taxonomy. For these I have tried to use suitable descriptive terms or phrases often without intending precise definition. I quite agree with Mr. Weatherby's views that: "An attempt to find other characters which, even if seemingly incapable of altogether definite statement, could be more easily seen and better relied upon, seemed worthwhile."[1] I have used many of the characters that he introduced and some new ones.

Although it was not my original purpose to enter into the general classification of the genus in any way, it finally did seem necessary to give formal recognition to the major groups of species. The erection of the series has caused in turn some slight readjustments within the subgenus. These changes are presented in the synopsis of the subgenus.

The Background of the Study

L. M. Underwood was the first botanist to give serious attention to the *Selaginella rupestris* group. His first paper, in 1898[2], clearly expressed the condition of the classification at that time: "The variations of the species of *Selaginella* with many-ranked leaves have long been a puzzle to botanists . . . . Two clearly marked species from North America have been separated from the tangle already; . . . . there remain . . . . the widely varying forms that for the past forty years have found an unsatisfactory resting place under S. *rupestris*." Underwood described a total of nine new species in unraveling "the tangle"; I maintain seven of them.

He was in correspondence with Hieronymus at Berlin and they exchanged specimens of many species in the group. Hieronymus did the *Selaginellaceae* for Engler & Prantl's 'Natürlichen Pflanzenfamilien'[3] and prior to and following this work described many new species in the genus. In the S. *rupestris* group he pro-

[1] Jour. Arn. Arb. 25:409. 1944.
[2] Bull. Torr. Bot. Club 25:125–133. 1898.
[3] Nat. Pflanz. 1^4:621–715. 1901.

posed twenty-eight species[4] of which I recognize eleven. Hieronymus deserves credit for his general position that a multiplicity of species existed and for his attempts to work them out. His work suffered for reasons that were largely either beyond his control or else in harmony with the times. His material was scrappy and inadequate, sometimes hopelessly so. Also his concepts of the natural distribution of species, particularly those of the United States, were not well developed. Finally, he relied largely upon quantitative characters of the leaves, setae and cilia, many of which have proved to be of little value. The considerable number of his species that are valid is probably due to the fact that he did have material of many species.

The last worker to describe many species was Maxon[5] who published eight new ones from the United States. All but three of these I recognize as valid and two of those three are recognized as varieties. Maxon not only described most of the new species remaining in the United States but in his treatments of *Pteridophyta* for various floras of the western United States he supplied keys for their identification. The work of Underwood and Hieronymus was largely consolidated and systematized by Maxon and a knowledge of most of the species of the United States was placed on a firm foundation by him. His knowledge and judgment of the species were excellent but probably because his work in the genus was primarily floristic he separated the species on the most convenient characters and did not develop a set of characters useful for the whole group. Also, he relied in his descriptions too strongly, in my opinion, on quantitative characters.

Prior to the studies of Underwood, Hieronymus and Maxon, the species were poorly understood. The most common policy was to place all material under the name of *Selaginella rupestris;* a few authors segregated varieties or forms of it; a very few segregated species. This early work is reviewed although it did not play an important role in the classification of the group.

The species named *Lycopodium rupestre* by Linnaeus[6] was, as many he treated, previously well known. Among several earlier figures of the species, that of Dillenius[7] is the best. It presents an excellent illustration of the plant from Virginia. Linnaeus combined Virginian and Siberian plants in the same species and this broad range was enlarged upon by later authors until finally S. *rupestris* was credited with essentially a world-wide distribution. At that time it included many diverse species. Beauvois[8] segregated *Selaginella* and other genera from *Lycopodium* in 1805. He placed *Lycopodium rupestre* in his genus *Stachygynandrum*. Spring, Milde and A. Braun were the principal monographers of *Selaginella* in the nineteenth century and they recognized, to a greater or lesser extent, the variability within S. *rupestris.* Spring[9] grouped his material on the

[4] Most of them in Hedwigia 39:290–320. 1900.
[5] Most of them in Smiths. Misc. Coll. 72^5. 1920.
[6] Sp. Pl. 2:1101. 1753.
[7] Hist. Musc. t. 63, fig. 11. 1741.
[8] Prodr. Aetheog. 101. 1805.
[9] Nouv. Mém. Acad. Roy. Belg. 24:57. 1850.

basis of habit, the rather short-stemmed northern species forming his S. *rupestris* var. *borealis* and the generally elongate and lax southern ones his var. *tropica*. Milde[10] used an essentially geographic segregation, recognizing as *formae* of S. *rupestris* material from several countries and regions. Of the ten forms he lists, I recognize seven as species. A. Braun[11] also recognized variants of S. *rupestris* as they occurred in Africa, using some obvious characters of the leaves, cilia and setae. Primarily due to floristic work, by the time of Underwood's treatment the following species were usually recognized as distinct from S. *rupestris:* S. *Dregei* Presl, S. *tortipila* A. Br., S. *oregana* D. C. Eaton and S. *echinata* Baker.

The present authority on the genus as a whole, A. H. G. Alston, has treated a number of species in the S. *rupestris* group, especially as they have occurred in his regional treatments. Outside of the United States and Mexico the species are rather few and he nowhere has had to deal with a sufficiently large number to seriously engage the problem of specific characters. His work may be ranked with that of Maxon, placing our knowledge of the species of South America, Africa, Madagascar, India, China and northeastern Asia on a firm foundation.

It will be noted that the species of Mexico had not been treated. This was probably due to the feeling that there was not sufficient material available to make it possible to deal successfully with the many species suspected of being present. The first worker to accept this difficult problem was C. A. Weatherby[12, 13]. In his two papers he was the first, from the point of view of this treatment, to derive a general set of specific characters and to start grouping the species into natural units; he was also the first to understand the special nature of the S. *rupestris* group and to adapt his classification to it. Mr. Weatherby's publications on *Selaginella* epitomize rather well his publications in systematics as a whole. His output was not voluminous but he had a strong predilection for the poorly understood groups and in these his abilities resulted in treatments of basic and permanent value. It will be apparent to students of his papers that the present study is largely an extension of his work. This is fitting for my interest in the group stemmed from his.

Morphology and Life History

Most of the species have prostrate, superficial stems that are variously disposed to form a mat of more or less distinctive type. The stems of a mat may be interlaced and intricate as in S. *Underwoodii* (fig. 40) and S. *cinerascens* or discrete as in S. *densa* (fig. 47). The branching may produce a very compact mat as in S. *Watsonii* (fig. 49) or a loose, open one as in S. *mutica*. Growing conditions affect the form of the mat so that it is not stable in most species. Edges of cliffs, steep slopes, boulders and seepage crevices modify the habit of growth. In addi-

---

[10] Fil. Europ. Atlant. 260–263. 1867.
[11] Kuhn, Fil. Afr. 212–214. 1868.
[12] Amer. Fern Jour. 33:113–119. 1943.
[13] Jour. Arn. Arb. 25:407–419. 1944.

tion, some species may have the central stems crowded and rather erect and the peripheral ones closely prostrate and widely creeping. In S. *tortipila* the two types were described as separate species. A similar condition exists in S. *Hansenii* although fortunately they were not segregated. In these species the size of the mat is increased by growth of the apical buds. The older portions of the stems die progressively toward the apical buds and strobili. The dead portions may be rather evenly distributed throughout the mat or, especially in the species with discrete branches, they may be in the center or at one side (fig. 47). A strobilus-bearing branch dies completely since the strobili, with rare exception, are determinate. Vegetative apices are theoretically indeterminate although actually they do occasionally die.

The species of *Arenicolae,* with rhizomes or basal branch buds, form various shaped clumps or mats depending upon the extent to which the substrate permits or hinders the growth of the rhizomes or basal buds. S. *arenicola,* which usually grows in open sand, has quite symmetrical mats. In the species with rhizomes, as S. *Weatherbiana,* the rhizomes grow forward, occasionally branching or producing erect, aerial stems. These aerial branches produce a branch-system on which strobili are eventually produced and a short time later the whole branch-system dies. Most of the apices die due to the determinate strobili produced although the vegetative tips also die. This may be due to the death of the portion of the rhizome beneath the aerial branches or because of the distance the apices have grown from the nearest roots. New aerial branches produced by the younger parts of the rhizome perpetuate the plant. The leaves of the rhizome are generally similar to those of the aerial stems (compare figs. 7 and 8) but are usually broader, thinner, have a shorter seta and cilia, have a less-developed dorsal groove and the living ones are pale tan or a very pale green. S. *arenicola* and S. *rupincola* lack rhizomes but have short buds at the base of the erect aerial stems (figs. 1, 5). These buds become active upon the death of the branch-system; each developing into a new branch-system. This results in a rather bushy habit unless, as is often the case in S. *rupincola,* growth is modified by rock crevices.

The stems often branch dichotomously but this is not the predominant type of branching in any of the species. The branching pattern is formed by laterals variously subordinate to the main stem, distance between branches and the angle at which they depart from the stem. Although this is obviously different in some species the degree to which it may be modified by growing conditions makes it an unreliable taxonomic character. A branch will remain subordinate to the stem upon which it is borne until the two apical buds are sufficiently removed from each other and then it will grow more rapidly. This seems to occur at about the time the stem and branches are separated by the death of the older portions. Branches of the second and third order are also subordinate to their respective main stems. In three species, S. *utahensis,* S. *leucobryoides* and S. *asprella,* the stems are fragile when dry and are easily broken even with careful handling. The anatomical nature of this character has not been investigated.

During periods of unfavorable growing conditions the stems become dormant. It is probable that many species have the ability to remain alive in the dormant state for many months. A specimen of S. *Watsonii* was planted three months after it had been pressed and dried and it put forth new growth. Part of a mat of S. *densa* var. *densa* was planted six months after it had been collected and stored as an herbarium specimen and it also grew. Various changes take place when the stem becomes dormant. In many species the branch tips curl upward; in *Eremophilae* they become involute. A considerable portion of the stem is involved and the dormant stems form ringlets in S. *oregana*. This curling of the stems recalls the behavior of S. *lepidophylla* and its relatives, the commercial Resurrection Plant. The leaves also change position, becoming more or less closely appressed to the stem. These changes are particularly marked in the strongly dorsiventral species in which the spreading lateral leaves almost completely enfold the upper ones. However, the erect upper leaves do not perceptibly change in position. In some species as S. *tortipila* the leaves are usually rather closely appressed in the growing state and change position very little when desiccated. The difference in position of the leaves of a species in the growing and dormant states is not sufficiently constant for general application. This behavior, however, has a distinct advantage to the taxonomist for it renders herbarium material as useful and as valid as living material for most characters of the plant. Conclusions as to the relation of living to herbarium material were confirmed by comparisons of specimens collected from species growing in the greenhouse. There is no difference between the living dormant plant and the herbarium specimen prepared from it. Soaking the specimen in water will restore it in the same way as watering the living plant. Specimens prepared from actively growing plants will assume the characters of the dormant state upon drying with the exception that portions subject to pressure in pressing will be held in more or less the original position.

I have not measured the growth of the stem of any species in its native habitat but measurements of material grown in the greenhouse indicate that it usually amounts to 1–4 cm. a year. During 100 days in the greenhouse, S. *arenicola* ssp. *Riddellii* grew 30 mm. and S. *viridissima* grew 15 mm. although this may not reflect the relative growth rates of the species in their natural habitats. A specimen of S. *tortipila* (*Hunnewell 9478*, GH) appears to show annual growth of 13 mm. on some of the stems.

The leafy stem is radially symmetrical in many species, that is, the leaves are disposed in the same manner on all sides of the stem at a given place and they are of the same size, shape, color and texture. This is true of the species that have erect stems and many of those that are prostrate. Most of the species with stems rather closely appressed to the ground are more or less dorsiventral. Extreme dorsiventral species such as S. *Landii* (figs. 62, 63) and S. *echinata* have the under leaves tightly appressed to the stem, the upper erect, the lateral ascending-curved, the under leaves longer than the upper, different in shape, thinner, tan or brownish, and the setae also differ. All intermediate conditions occur, some species having

one or more dorsiventral characters so that there is not a sharp line of distinction between radial and dorsiventral symmetry.

Leaves are the most useful part of the plant for purposes of taxonomy and a number of characters of the position, base, apex, shape, texture, cilia and seta have been used in this treatment. The base of the leaf, in some species, is abruptly adnate to the stem and distinct from it in color. In other species the leaf-base is decurrent, gradually blending into the stem in form and color. Red leaves often occur in S. *Sartorii*, S. *Steyermarkii* and S. *Hansenii*, especially in the area between the oldest living leaves and the youngest dead ones. (fig. 23, the dark portions of the leaves are red). These are often a bright red or tinged with purple. They perhaps develop color in a manner similar to the sugar maple and other deciduous trees in northern regions. A few double leaves have been observed. The leaves are firm in texture with the exception of S. *oregana* in which they are sufficiently soft and thick so that they partly collapse in drying.

The usual sequence of leaf development appears as follows. At the beginning of the growing season relatively few green leaves are present at the apex of the stem but renewed growth of the apical bud produces new leaves and a conspicuous zone of green leaves develops. After a time the oldest of these die; those that were green at the start of the growing season die first. Under rather uniform conditions the death of the older leaves proceeds at a rather constant rate and probably at a rate similar to the production of new leaves so that a zone of green leaves of rather uniform length is maintained. During 100 days in the greenhouse, leaves died on 11 mm. of stem in S. *mutica* and on 39 mm. in S. *arenicola* ssp. *Riddellii.* Toward the end of the growing season, or with the advent of a dry period, the leaves continue to die, although no new ones are produced, until sometimes only a few green leaves near the bud remain.

The apparent inhibition of growth of lateral branches has been discussed. In some species the leaves are affected in a similar manner. In S. *cinerascens*, for example, the leaves on the main stem are the longest and those on the primary, secondary and tertiary branches progressively shorter. However, once the branch apex is separated from the stem apex by the death of the older portions, the leaves that are produced are as large as those on a main stem.

The strobilus is nearly always determinate but vegetative growth from its apex does occur. This is not uncommon in S. *arenicola* ssp. *Riddellii* and I have seen two other examples of the condition: S. × *neomexicana* (*Slater 3*, US) and S. *arizonica* (*A. & R. A. Nelson 1158*, MO). This condition was noted in S. *densa* planted in the greenhouse in a dormant condition that produced vegetative tips on two strobili upon renewal of the growth of the mat. I have seen one strobilus that was dichotomous (*Soxman 351*, US), a specimen of S. × *neomexicana.* In most species the sporophylls die progressively upward after the death of the leaves on the leafy branch beneath. In S. *arenicola* ssp. *arenicola* and ssp. *acanthonota,* and to some extent in S. *Dregei* and S. *tortipila,* the apical sporophylls die first and the basal last, and this occurs prior to the death of the leaves beneath so that the death of the strobilus is independent of the progressive death of the leaves.

The sporophylls are hinged by their stalks to the strobilus axis and when the spores mature and the sporangia open they move outward presumably in response to their water content. This movement evidently aids in the dispersal of the spores. Although I am not certain, the two valves of the sporangium may also move. I have observed in S. *rupestris* that megaspores will frequently remain in the basal sporangia after all of the others are shed, apparently because the leaves directly beneath do not allow the sporophylls to move sufficiently. Occasionally spores are found in dead strobili, and thus their liberation from the sporangium is not always effected.

I have seen sporelings in only a single collection and germinated megaspores were never observed on the specimens. Megaspores were germinated on filter paper in a petri dish and then were dried. The triradial split in the spore coat and the gametophyte were still evident; thus if germinated megaspores had occurred in the collections they could have been recognized. Lyon [14] reports germination of the megaspores within the sporangium, and fertilization of the gametophyte prior to dispersal from the sporangium. I have observed nothing to support this but since the species do have natural ranges, many of them over considerable areas, it would seem that the normal life cycle is completed. Possibly germination and fertilization occur at rather rare intervals when the microclimate is particularly favorable. This may occur in the sporangium, as Miss Lyon observed, or after the spores have been shed. Since the stems of most species are quite tough and difficult to break, and are usually anchored at frequent intervals by the rhizophores and roots it does not seem likely that vegetative reproduction could account for the distribution of the species. In the group of species with fragile stems, S. *utahensis*, S. *leucobryoides* and S. *asprella*, it is not unreasonable to consider that fragments might be dispersed by the wind although actually they are all rather local endemics. Their restricted ranges, however, may be due to other causes and they may still possess an effective means of dispersal.

In S. *rupestris*, which is apogamous throughout much of its range, fertilization is not a factor and the megaspores may be effectively dispersed immediately upon release from the sporangium. S. *rupestris* has the widest distribution of any species in recently available areas and its range may be taken to illustrate the effectiveness of megaspore dispersal. I have seen sporelings growing in the soil among the stems of a mat of S. *sibirica* (*Calder & Billard 2995*, MO). These are about 1 cm. long and inside the megaspore a foot can be seen from which are produced one to three roots and an erect stem. This stem does not bear leaves for the first third to half of its length. The first leaves are thinner, more elongate at the base and more widely spaced than the adult leaves. Those at the tip of one of the sporelings are of the adult type in aspect and disposition; the other two sporelings have only juvenile leaves. Two rhizophores had been produced on each sporeling, the first in the axil of the second or third leaf.

---

[14] Bot. Gaz. 32:124–141. 1901.

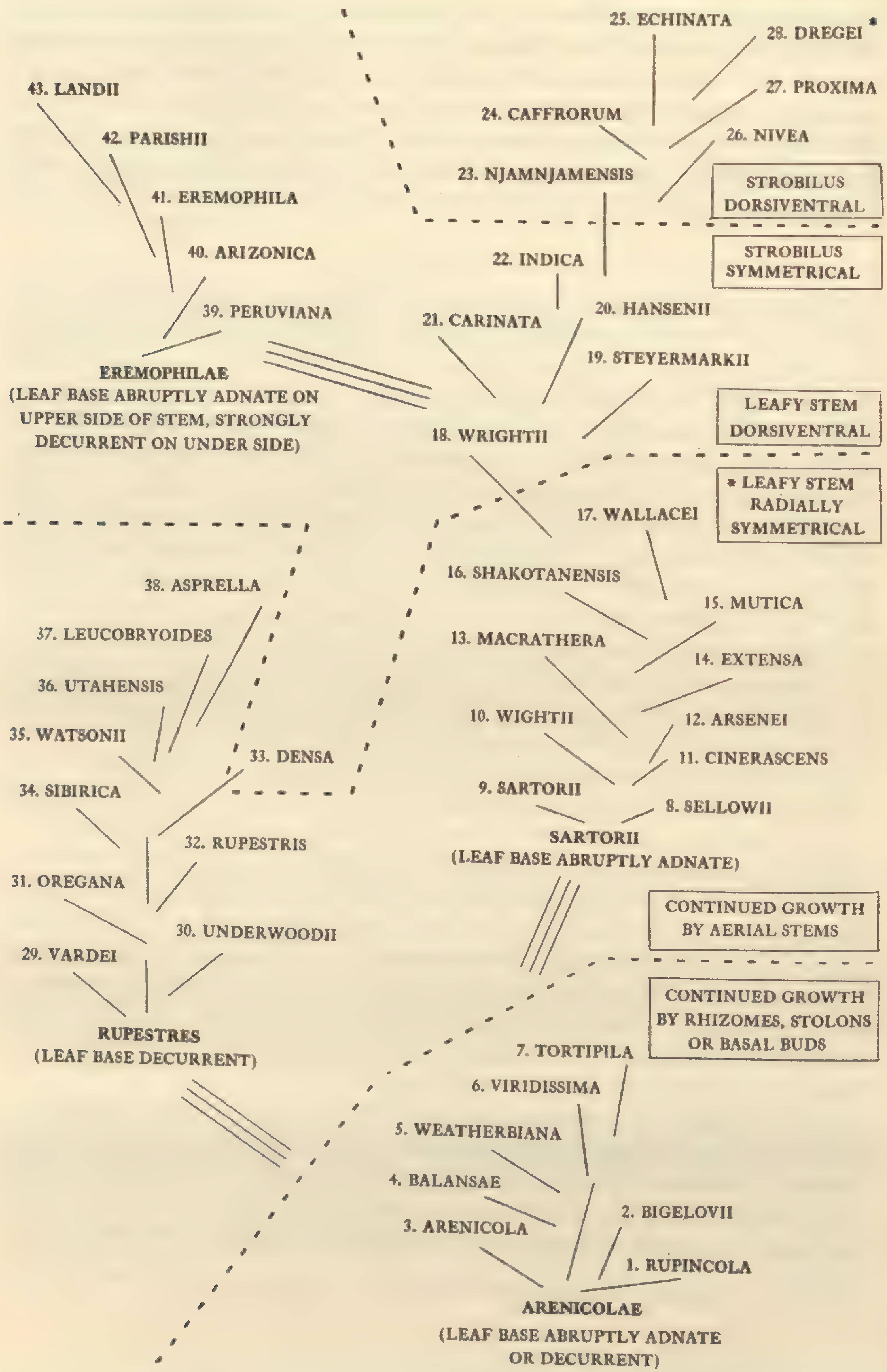
The chromosome number has been determined in S. *Weatherbiana* (*Tryon & Tryon 5077*, 2n = 18), *S. mutica* (*Tryon & Tryon 5073*, n = 9, 2n = 18) and in S. *Bigelovii* (*Tryon & Tryon 5054*, n = 9). The sporophytic counts were made from the tips of rhizophores and the gametic ones from the contents of the megasporangia at meiosis. I am indebted to Dr. Amy Gage Skallerup for the considerable work involved in making these counts. These numbers agree with the ones for S. *selaginoides* (S. *spinulosa*), S. *helvetica* and S. *denticulata* given by Miss Manton[15] as n = 9.

Phylogeny

The phyletic chart portrays the general relationships of the series and the species within them. There is not sufficient evidence of the actual course of evolution to more than indicate in very general terms the origin of the series. The characters that are of particular importance in determining a primitive or advanced phyletic position are the nature of the leaf-base, abruptly adnate or decurrent, the presence or absence of rhizomes, stolons or basal buds and the symmetry of the leafy stem. *Arenicolae* is placed as primitive because it exhibits some characters of Section *Selaginella*, the most primitive section of the subgenus. The comparison is particularly effective between S. *arenicola* and S. *rupincola* of *Arenicolae* and the two species of Section *Selaginella*, S. *selaginoides* and S. *deflexa*. These four species have erect strobilus-bearing branches and have rhizophores borne only at the base of the stem. S. *rupincola* is not entirely uniform in the latter character in that occasional prostrate stems may have rhizophores borne throughout. S. *deflexa* is similar to S. *arenicola* and S. *rupincola* in that the vegetative branches are rather small and resume active growth upon the death of the strobilus-bearing branch above them. Thus S. *arenicola* and S. *rupincola* are the most primitive types in the section. This does not mean that they are actually ancestral to the species of the series or that they represent the transition from Section *Selaginella* to Section *Tetragonostachys*; but rather that they retain the ancestral characters to a greater degree than the other living species. *Eremophilae*, on the basis of its leaf-base characters, is considered to be the most advanced and *Sartorii* and *Rupestres* occupy a mid-position. Due to the limitations of space and the diversity of *Sartorii* it has not been possible to portray accurately the phyletic level of *Rupestres*. The radially symmetrical species of *Sartorii* are considered as more primitive than *Rupestres*, those with dorsiventral leafy stems and symmetrical strobili essentially on the same level and the species with dorsiventral strobili more advanced.

It will be noted that the habit of growth is uniform in the *Sartorii*, *Rupestres* and *Eremophilae* and distinct from that in the *Arenicolae*. The leaf-base characters behave in a different manner; they are stable and distinctive in *Sartorii*, *Rupestres* and *Eremophilae* but are variable in *Arenicolae*. The series *Sartorii* and *Rupestres* are regarded as differentiating from *Arenicolae* or its ancestors, the characters of

[15] Manton, I. Problems of cytology and evolution in the Pteridophyta. p. 259. 1950.



Phyletic chart of subgenus *Selaginella* section *Tetragonostachys.*

the leaf-base becoming fixed in each series and the same type of growth developing independently. The *Eremophilae* were derived from the *Sartorii* by further specialization of the leaf-bases. The development of the dorsiventral leafy stem has occurred independently in *Sartorii* and *Rupestres*. S. *Dregei*, with its radially symmetrical leafy stem and unilateral strobilus, poses a problem. Perhaps the radial symmetry is primitive and S. *Dregei* should be placed apart from S. *echinata* and S. *proxima*, or perhaps, as the chart implies, it may be derived from species with dorsiventral leafy stems.

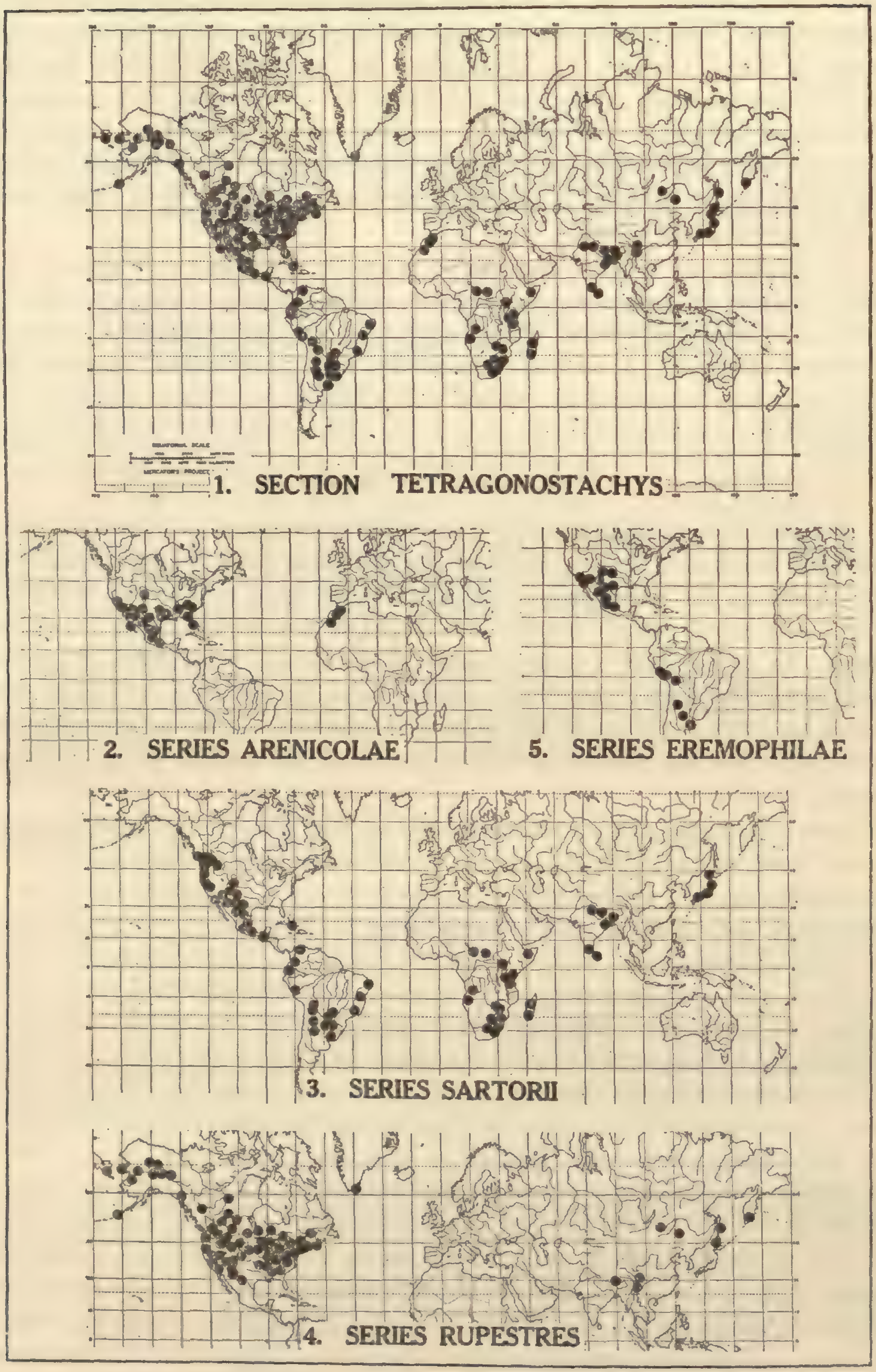
The evolutionary relation of the species is usually not known although in a few cases it is fairly clear that one is ancestral to another, or more likely, that the two have had a common ancestor. Within each series the most specialized species are considered advanced. The species that exhibit few if any special structures and which may have characters in common with a less advanced series are considered primitive.

Geography and Ecology

Section *Tetragonostachys* (Map 1) occurs in temperate and tropical North and South America; it is absent from the Amazon basin, Central America and, with few exceptions, the colder regions. Its distribution is not as extensive in the Old World. In Asia it occurs in India and the Himalayan region and in Japan and Siberia. In Africa there is a single species in the region of the Atlas Mountains; the others occur south of the Sahara, with a better representation in eastern than in western Africa. Three species grow in Madagascar. The section is notably absent from the Malaysian-Australian region, from the Pacific Ocean and from Eurasia.

Series *Arenicolae* (Map 2) extends more or less laterally across the southern United States and adjacent Mexico with an isolated species in northwestern Africa —a distribution not unlike that of the genus *Platanus*. *Sartorii* (Map 3) has a range much like that of the whole section except for its absence from boreal regions and from northwestern Africa. *Rupestres* (Map 4) is predominantly North American with a single species in northeastern Asia and one in the Himalayan region. It is the only series that has a distribution of any extent in areas of Pleistocene continental glaciation. The ranges of S. *densa* (Map 43), S. *sibirica* (Map 47) and S. *rupestris* (Map 42) are partly in these areas. S. *rupestris* occupies more glaciated territory than the others and it is undoubtedly significant that there it is apogamous. *Eremophilae* (Map 5) is New World with essentially an Andean distribution. It is absent in the American tropics from northern Peru to southern Mexico.

Most of the forty-three species of the section grow in the United States and Mexico. The two countries have a total of thirty species which represent all but two of the species of the New World. The United States has twenty-one species of which ten are endemics, while Mexico has sixteen species and five endemics. The southwestern United States—Texas to southern California—is the richest area


1. SECTION TETRAGONOSTACHYS
2. SERIES ARENICOLAE
5. SERIES EREMOPHILAE
3. SERIES SARTORII
4. SERIES RUPESTRES

with a total of seventeen species. Ten species, four of them endemic, grow in California and eight species in Texas. There are three species in Canada, two in Alaska, one in Cuba, one in Guatemala and four in South America. Africa has five species, four of them endemics, Madagascar three endemic species, India and the Himalayan area three species, two endemic, and northeastern Asia two species, one of them endemic.

Most of the species have continuous ranges, minor discontinuities probably being due to insufficient collecting. The important and apparently authentic examples of discontinuous range are the following. Both S. *Sellowii* (Map 17) and S. *Sartorii* (Map 18) are disjunct between Mexico and northern South America and the former species has an isolated station in Cuba. S. *peruviana* (Map 52) is similar but the disjunction is wider. S. *Wightii* (Map 19) grows in southern India and Ceylon and in Africa; S. *rupestris* (Map 42) has an isolated station in southern Greenland.

Most of the species of each series are allopatric in their distribution and, with two exceptions, the relatively few cases of sympatric species are ecologically separated. The examples I know in which two species of the same series actually grow together are S. *densa* and S. *rupestris* in Canada and S. *peruviana* and S. *arizonica* in Texas. The latter pair may sometimes grow in the same mat.

There are two important ecological features of the species. They are mostly plants of dry habitats and they usually do not thrive in the presence of other plants. Consequently they are most abundant in regions of moderate rainfall, or in locally dry habitats in moist areas, and they grow in rocky, gravelly or sandy places, or on cliffs or barren soil where there is a minimum of other vegetation. One species, S. *oregana,* is usually an epiphyte and another, S. *extensa,* occasionally is. Many of the species grow in acid soil or on acid rocks; a few of them will also grow on basic rocks; a single species, S. *Wrightii,* is definitely a calciphile. There is little evidence that they are important pioneers, being notably few in glaciated areas and in rocky places recently disturbed by fire or lumbering. Rather their chief role seems to be to fill the niche of locally transient but regionally permanent open, xeric habitats.

The plants are not especially adapted either for the prevention of water loss or for its storage. The minor adaptations that are present in the form of fleshy and cutinized leaves are not sufficient to prevent frequent drying. The ability to survive desiccation undoubtedly resides in unusual physical and chemical properties of the cell contents. The extensive network of roots, borne close to the surface, enables the plants to utilize rapidly even small amounts of moisture. The species probably can grow in relatively moist places, as a few of them do, but because of their inability to compete with other plants, these habitats are not often available. They are restricted to the open habitats, which in a given area are usually the most xeric, where their special ability to survive desiccation allows them to be successful.

Distribution Maps

A solid dot is used on the maps to indicate the location of a collection seen; in a few cases a circle is used to represent a specimen from a general region. In S. *arenicola,* half-dots are used to represent intermediates between the subspecies. Literature records, indicated by an X, have been used when they significantly augment the range and when there is no doubt about the identity of the species. Except for S. *Balansae,* all of the literature records have been taken from the various papers of A. H. G. Alston.

Acknowledgments

I am indebted to the curators of the herbaria of the following institutions for the generous loan of material. Botanisches Museum, Berlin-Dahlem, British Museum (Natural History), Chicago Natural History Museum, Gray Herbarium, Department of Botany, University of Minnesota, New York Botanical Garden, Muséum National d'Histoire Naturelle, Paris, United States National Herbarium and Department of Botany of Yale University. The abbreviations for these and other herbaria are taken from Index Herbariorum, part I (Regnum Vegetabile, vol. 2).

I wish to thank Mr. A. H. G. Alston and Mr. J. A. Crabbe of the British Museum, Mr. F. Ballard of Kew, Mme. Tardieu-Blot of Paris, Dr. H. Reimers of Berlin, and Mr. C. V. Morton of the United States National Herbarium for courtesies extended during the course of this study.

Systematic Account

SYNOPSIS OF SELAGINELLA SUBGENUS SELAGINELLA[16]

Selaginella Beauv. Prod. Aethog. 101. 1805, conserved name. Type species: *Selaginella selaginoides* (L.) Link.

Subgenus Selaginella (Section *Homoeophyllae* Spring, in Mart. Fl. Bras. 1:118. 1840. *Homotropae* A. Br. Ind. Sem. Hort. Bot. Berol. 1857: Append. 11. 1857, without rank. Subgenus *Euselaginella* Warb. Monsunia 1:100. 1900. Subgenus *Homoeophyllum* (Spring) Hieron. in Engl. & Prantl, Nat. Pflanz. 1^4:669. 1901.). Sporophylls uniform or similar, leaves uniform or gradually dimorphic. Type species: *Selaginella selaginoides* (L.) Link.

Section Selaginella (*Cylindrostachyae* A. Br. loc. cit., without rank. Section *Cylindrostachys* (A. Br.) Hieron. loc. cit.). Strobilus cylindrical, leaves spirally arranged. Type species: *Selaginella selaginoides* (L.) Link. species: 1. S. *selaginoides* (L.) Link, 2. S. *deflexa* Brack.

[16]Partly adapted from Walton & Alston, in Verdoorn, Man. Pterid. 503. 1938.

SECTION **Tetrastichus** (A. Br.) Tryon, stat. nov. (*Tetrastichae* A. Br. loc. cit., without rank). Strobilus tetragonous, at least the lower leaves decussate. Type species: *Selaginella pumila* (Schlecht.) Spring. SPECIES: 1. S. *pygmaea* (Kaulf.) Alston (S. *pumila* (Schlecht.) Spring), 2. S. *gracillima* (Kze.) Alston (S. *Preissiana* Spring), 3. S. *uliginosa* (Labil.) Spring.

SECTION TETRAGONOSTACHYS (A.Br.) Hieron. loc. cit. (*Tetragonostachyae* A. Br. loc. cit., without rank). Strobilus tetragonous, leaves spirally arranged. Type species: *Selaginella rupestris* (L.) Spring.

SERIES **Arenicolae** Tryon. Type species: *Selaginella arenicola* Underw. SPECIES: 1. S. *rupincola* Underw., 1a. S. × *neomexicana* Maxon, 2. S. *Bigelovii* Underw., 3. S. *arenicola* Underw., 3a. ssp. **Riddellii** (Van Eselt.) Tryon, 3b. ssp. **arenicola**, 3c. ssp. **acanthonota** (Underw.) Tryon, 4. S. *Balansae* (A. Br.) Hieron., 5. S. *Weatherbiana* Tryon, 6. S. *viridissima* Weath., 7. S. *tortipila* A. Br.

SERIES **Sartorii** Tryon. Type species: *Selaginella Sartorii* Hieron. SPECIES: 8. S. *Sellowii* Hieron., 9. S. *Sartorii* Hieron., 10. S. *Wightii* Hieron., 10a. var. **Wightii**, 10b. var. *Phillipsiana*, 11. S. *cinerascens* A. A. Eaton, 12. S. *Arsenei* Weath., 13. S. *macrathera* Weath., 14. S. *shakotanensis* (Franch. ex Takeda) Miyabe & Kudo, 15. S. *Wallacei* Hieron., 16. S. *mutica* D. C. Eaton ex Underw., 16a. var. *limitanea* Weath., 16b. var. **mutica**, 17. S. *extensa* Underw., 18. S. *Wrightii* Hieron., 19. S. *Steyermarkii* Alston, 20. S. *Hansenii* Hieron., 21. S. **carinata** Tryon, 22. S. **indica** (Milde) Tryon, 23. S. *njamnjamensis* Hieron., 24. S. *caffrorum* (Milde) Hieron., 25. S. *echinata* Baker, 26. S. *nivea* Alston, 27. S. **proxima** Tryon, 28. S. *Dregei* (Presl) Hieron.

SERIES **Rupestres** Tryon. Type species: *Selaginella rupestris* (L.) Spring. SPECIES: 29. S. *Vardei* Lév., 30. S. *oregana* D. C. Eaton, 31. S. *Underwoodii* Hieron., 32. S. *rupestris* (L.) Spring, 33. S. *densa* Rydb., 33a. var. **scopulorum** (Maxon) Tryon, 33b. var. **densa**, 33c. var. **Standleyi** (Maxon) Tryon, 34. S. *sibirica* (Milde) Hieron., 35. S. *Watsonii* Underw., 36. S. *utahensis* Flowers, 37. S. *leucobryoides* Maxon, 38. S. *asprella* Maxon.

SERIES **Eremophilae** Tryon. Type species: *Selaginella eremophila* Maxon. SPECIES: 39. S. *peruviana* (Milde) Hieron., 40. S. *arizonica* Maxon, 41. S. *eremophila* Maxon, 42. S. *Parishii* Underw., 43. S. *Landii* Greenm. & Pfeiff.

KEY TO THE SERIES OF SECTION TETRAGONOSTACHYS

a. Stems erect or ascendent with rhizophores produced only at or near the base, rarely one or a few stems of a group prostrate with rhizophores produced nearly throughout; subterranean rhizomes or ground-level stolons or basal branch buds present .... Series *Arenicolae*, p. 18

a. Stems prostrate to decumbent, or irregularly ascendent, with rhizophores produced at or near the apex, at least of the primary stems (the branches may rarely be erect), or epiphytic and long-pendent with rhizophores produced only at the base; rhizomes and stolons absent, basal branch buds rarely and irregularly present. b.

b. Leaves with the base abruptly adnate and distinct from the stem in color[17] on all sides of the stem, or especially on the branches, those on the main stem rarely decurrent .... Series *Sartorii*, p. 31

b. Leaves with the base decurrent on all sides of the stem[17] or at least those on the underside strongly decurrent. c.

c. Upper leaves with the base usually decurrent; leafy stem radially symmetrical to definitely dorsiventral, the zone of green leaves[18] about equal on all sides of the stem; branch tips straight or slightly curled in the dormant condition .... Series *Rupestres*, p. 58

c. Upper leaves with the base abruptly adnate, distinct from the stem in color (rarely a distinct stem-ridge may be present); leafy stem strongly dorsiventral, the zone of green leaves[18] well developed on the upper side of the stem, very short to absent on the under side; branch tips involute in the dormant condition .... Series *Eremophilae*, p. 76

SERIES **Arenicolae** Tryon, ser. nov.

Rhizomata vel gemmae brevia simplicia ad bases caulium aeriorum hae saepe stolones producentes praesentia. Caules erecti vel ascendentes. Apices ramorum recti vel leviter curvati statu inerte. Caules frondosi radialiter symmetricales. Folia base decurrente vel abrupte adnata cum caule distincta colore. Typus: *Selaginella arenicola* Underw.

Plants terrestrial; rhizomes present, their leaves different from those of the aerial stem, thinner, with shorter setae, generally broader, with shorter cilia, with a less-developed dorsal groove, the living ones pale tan to a very pale green, *or* short, simple buds present at the base of the aerial stems, these sometimes elongated to form stolons, *or* both rhizomes and basal buds present. Stems erect or ascendent, with rhizophores produced only at or near the base, rarely one or a few stems (especially in *S. rupincola*) prostrate with rhizophores produced generally throughout; stems short to moderately so, forming distinct groups or in the species with

[17] To be observed between the first and third branches back from the apex of the stem.
[18] This character may be obscured by death of the leaves during a long dormancy.

rhizomes usually forming tall, loose mats. Branches short to moderately long, usually remote, discrete or intricate; branch tips straight or slightly curved in the dormant state. Leafy stems radially symmetrical, the leaves equal in position, length, shape and texture on all sides of the same portion of the stem, rarely slightly dorsiventral in position on prostrate stems; zone of green leaves equal on all sides of the stem or rarely slightly longer on the upper side. Leaves with the base abruptly adnate and distinct from the stem in color, to decurrent; dorsal groove evident from base to apex, or in S. *tortipila* absent or poorly developed; setae, if present, relatively straight and stout, without a modified tip, persistent, or in S. *tortipila* with a filiform, tortuous, usually deciduous tip.

Arenicolae is a homogeneous series although the species are quite distinct and show considerable diversity. The species are held together by the characters of the limited growth of the aerial branches and the rhizome or bud growth at the base of the branches.

The leaf-base which is such an important character in the other series is variable here. In S. *rupincola* and S. *Bigelovii*, the only two species that show a close affinity, the leaf-base is abruptly adnate to the stem and distinct in color. In S. *Balansae*, S. *Weatherbiana* and S. *viridissima* it is decurrent toward the base of the branches and tends to be abruptly adnate toward the tip. In S. *arenicola* and S. *tortipila* the leaf-bases are decurrent. The least specialized species appear to be S. *rupincola* and S. *arenicola*, while the most specialized, those with modified setae, are certainly S. *tortipila* and S. *viridissima*. No species shows an evident relation to a species of any other series.

KEY TO SPECIES

a. Leaves with the base abruptly adnate and distinct from the stem in color on all branches. b.

- b. Rhizomes absent; cilia of the leaves of a branch-system usually predominantly or entirely piliform, about ¼ as long as the width of the blade or longer, rarely only a few piliform; leaf-apex flat to rounded. Arizona to Texas, Tamaulipas to Sonora and southward .... 1. S. *rupincola*, p. 20
- b. Rhizomes present; cilia of the leaves of a branch system usually predominantly or entirely dentiform, about ⅛ to ⅙ as long as the width of the blade, rarely some or most piliform and longer; leaf-apex usually carinate to broadly rounded. California and Baja California .... 2. S. *Bigelovii*, p. 22

a. All or at least the basal leaves of the aerial branches and of the rhizomes (when present) with the base decurrent. c.

- c. Setae of the leaves stout, relatively straight, without a modified tip, persistent, or setae absent; dorsal groove evident from the base to the apex. d.
  - d. Leaves setate. e.

e. Rhizomes absent, short stolons occasionally present. Texas to Florida and North Carolina .... 3. S. *arenicola*, p. 23

e. Rhizomes present. f.

f. Leaf-apex flat to slightly rounded; setae tawny to whitish. Northwestern Africa .... 4. S. *Balansae*, p. 27

f. Leaf-apex strongly carinate; setae lutescent to greenish-white. New Mexico and Colorado .... 5. S. *Weatherbiana*, p. 28

d. Leaves muticous .... 6. S. *viridissima*, p. 28

c. Setae of the leaves usually with a long, filiform, tortuous, often partly or wholly deciduous tip, rarely the tip only irregularly flexuous, or the setae without a modified tip; dorsal groove absent or developed only in the mid-portion of the blade, rarely moderately developed but not extending to the base or apex .... 7. S. *tortipila*, p. 29

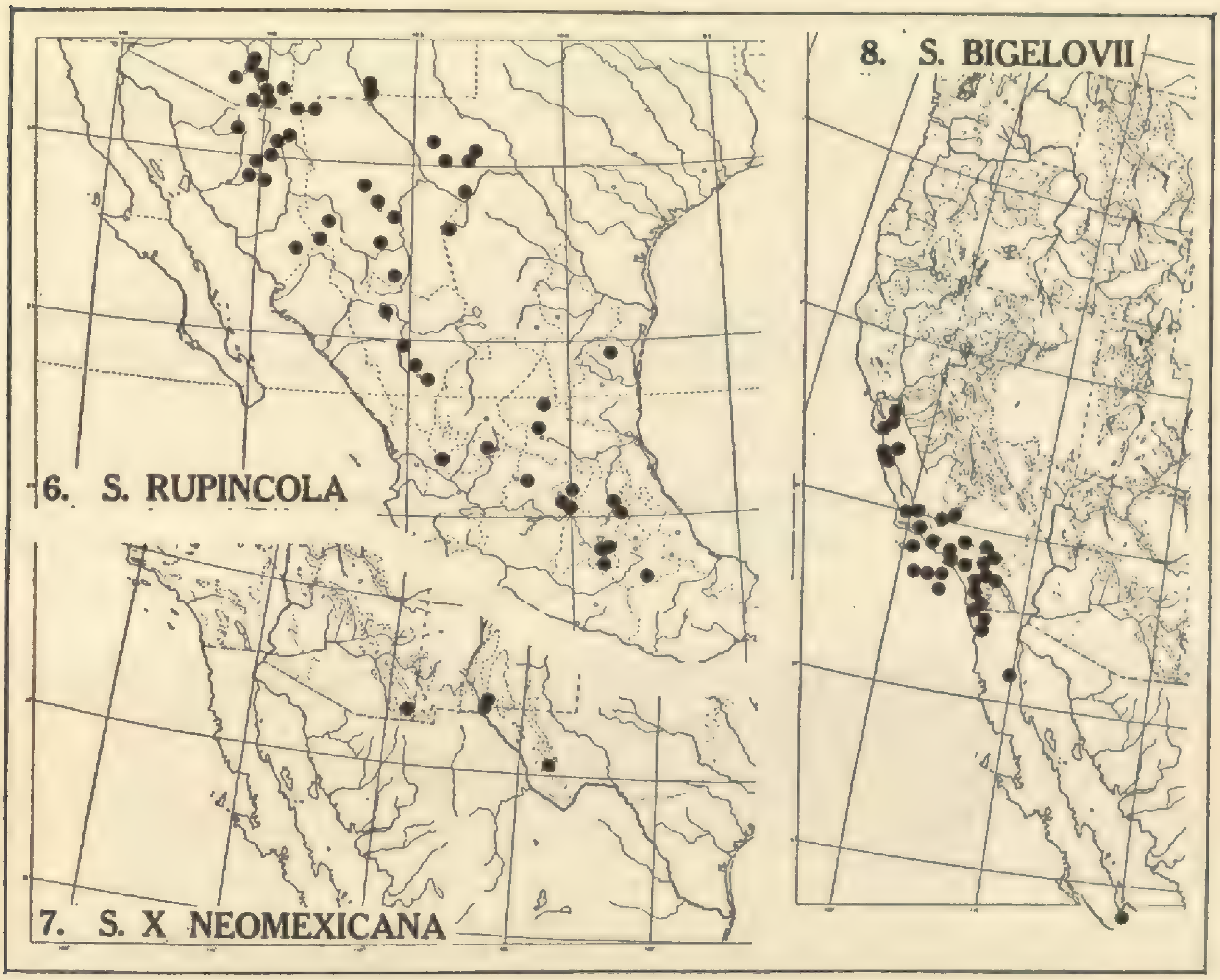
1. Selaginella rupincola Underw. in Bull. Torr. Bot. Club 25:129. 1898. (Lectotype: *Wooton 124* NY! marked by Underwood as type although he did not cite it as such. Paratypes: *Palmer 92* K; *Toumey* US!; *Wright 2116* NY!, US! cited by Underwood as *2106*). Figs. 1, 2. Map 6.

Selaginella Chrismarii Hieron. in Hedwigia 39:299. 1900, as *Chrismari.* (Holotype: *von Chrismar* B!; *Purpus 3156* F, GH, MO, US is identical).
Selaginella Chrismarii var. *Karwinskyana* Hieron. in Hedwigia 39:300. 1900. (Lectotype: *Palmer 554* B! chosen because of its wide distribution although at least at GH and US it is mixed with S. *peruviana*. Paratypes: *Karwinsky* B!; *Schaffner 11* B!).
Selaginella Chrismarii var. *Neeana* Hieron. in Hedwigia 39:300. 1900. (Holotype: *Née* B!).
Selaginella rupestris (L.) Spring var. *rupincola* (Underw.) Clute, Fern Allies, 142. 1905.

Rhizomes absent; aerial branches with buds present at their base, erect or ascendent, sometimes decumbent at the base, rarely one or some of the branches of a plant prostrate. Leaves with the base abruptly adnate, distinct from the stem in color; margins ciliate, the cilia usually piliform, ¼ as long as the width of the blade or longer, rarely some or most leaves with the cilia predominantly dentiform and shorter; apex flat to rounded to rarely carinate; setae milk-white and opaque or sometimes with a greenish-lutescent base, to whitish-lutescent and translucent. Megaspores rugose to rugose-reticulate, rarely nearly smooth on the outer face, pale orange.

S. *rupincola* is closely related only to S. *Bigelovii;* the two may be separated by the characters in the key. The long spreading cilia on the leaves are most characteristic but infrequently they may be rather short. In a very few specimens that I have seen the stems are prostrate but these may be distinguished from species of other series by the basal buds. A park supervisor in Arizona informed me that in times of drought this plant was browsed by deer.

Dry open places, on ledges and in crevices of cliffs, on rocky slopes or in talus, or in gravel, usually from 1000 to 2000 m., rarely up to 3500 m. It is apparently confined to igneous rocks.



Texas to Arizona, south to Puebla.

Representative specimens:

UNITED STATES. TEXAS: *Cory 48388* (GH); *Warnock 614* (GH, US), *20893* (F, MO). NEW MEXICO: Organ Mountains, Dona Ana Co., 5800 ft. July 10, 1897, *Wooton 124* (K, MO, NY, US); *Wright 2116* (sometimes as *2106*) (GH, K, MO, NY, US). ARIZONA: *Ferriss 26* (NY, US); *Maguire 10021* (GH, US); Santa Catalina Mountains, April 3, 1894, *Toumey* (US); *R. M. & A. F. Tryon 5050* (ARIZ, B, BM, DS, F, FI, GH, K, MICH, MO, NY, P, RM, UC, US), *5051* (CU, GH, MIN, MO, PH, POM, US, WS).

MEXICO. *Née* (B); 1827, *Karwinsky* (B). COAHUILA: *Johnston & Muller 307* (GH). CHIHUAHUA: sw. Chihuahua, *E. Palmer 92* in 1885 (GH, MO, US); *E. Palmer 38* in 1908 (B, F, GH, MO, US). SONORA: *Gentry 1194* (F, GH, MO, US); *Wiggins & Rollins 450* (GH, MO, NY, US). TAMAULIPAS: *Bartlett 10529* (F, US). DURANGO: city of Durango and vicinity, *E. Palmer 554* in 1896 (B, BM, F, GH, MO, US); *E. Palmer 485* in 1906 (BM, F, GH, MO, US). GUANAJUATO: Guanajuato, 1848, *von Chrismar* (B). JALISCO: Nov. 16, 1930, *M. E. Jones* (BM, GH, MO, US). DISTRITO FEDERAL: *Schaffner 11* (B, GH, US). PUEBLA: *Purpus 3156* (BM, F, GH, MO, US).

1a. SELAGINELLA × NEOMEXICANA Maxon, in Smiths. Misc. Coll. 72^5:2. 1920, as *S. neomexicana.* (= *S. mutica × rupincola*). (Holotype: *Wooton* in 1909 US! fragment GH!. Paratypes: *Wooton* in 1902 US!, in 1904 US!, in 1907 US! fragment MO!). Map 7.

The recognition of *S. × neomexicana* as a putative hybrid is based on its abortive spores and intermediate morphological characters. The sporangia and

spores are variously abortive in all of the specimens examined. No mature megaspores have been seen and in only one collection (*Wooton* in 1904) have I seen microspores of a size that might indicate maturity. These are probably also abortive, however, since they average some 22 μ in diameter, while the microspores of S. *rupincola* and S. *mutica*[19] range in size from 38 to 64 μ and from 30 to 53 μ respectively.

Although abortive sporangia and spores might be due to a number of causes, specimens with this character are intermediate in various degrees between the two proposed parental species. The erect to ascendent branches with buds at their base are characters of S. *rupincola* while the commonly linear-lanceolate leaves usually with a strongly carinate apex suggest S. *mutica.* Most specimens are rather intermediate but some, such as *Wherry* in 1925, are rather close to S. *mutica* while others, such as *Wooton* on January 9 and on September 28, 1909, are close to S. *rupincola.*

The distribution of the hybrid is within the range of both parent species and it is known to grow with both at some localities.

On open or shaded igneous rocks at about 1000–2000 m.

Texas to Arizona.

Representative specimens:

United States. texas: *Slater 2, 3* (US); *Knoblock 5557* (US); *Soxman 351* (US); April 26, 1925, *Wherry* (US); *Hinckley 3404* (GH, US). new mexico: March 3, 1907, *Wooton* (F, MO, US); Organ Mountains, Dona Ana Co., 6000 ft., Jan. 9, 1909, *Wooton* (GH, US); Sept. 28, 1902, *Wooton* (NY, US); Sept. 11, 1904, *Wooton* (US). arizona: Paradise, Cochise Co., 1904, *Ferriss* (GH, US).

2. Selaginella Bigelovii Underw. in Bull. Torr. Bot. Club 25:130. 1898. (Holotype: *Bigelow* NY!. Paratypes: *Coville & Funston 101* NY!; *Henshaw* NY! US!; *Parish & Parish 671* NY!; *Underwood* NY!). Fig. 3. Map 8.

Rhizomes widely creeping; aerial branches with buds often present at their base, erect, rarely some decumbent at the base. Leaves with the base abruptly adnate, distinct from the stem in color; margins ciliate, the cilia usually dentiform, about 1/8 to 1/6 as long as the width of the blade, less often some or most of the leaves with the cilia piliform and longer; apex strongly carinate to broadly rounded, or predominantly so; setae usually milk-white and opaque, to whitish, lutescent- or greenish-white, translucent. Megaspores rugose to rugose-reticulate, rarely nearly smooth on the outer face, lemon-yellow to pale orange.

S. *Bigelovii* is closely related to S. *rupincola* from which it differs by the presence of rhizomes in addition to the less important leaf characters mentioned in the key. It has been reported to be browsed by cattle in times of drought.[20]

This species usually grows in open places, on serpentine, sandstone or igneous rocks, in crevices or shallow depressions, on cliffs, at the base of boulders or in

[19] Tryon, A. F. in Ann. Mo. Bot. Gard. 36:418, 419. 1949:
[20] Wiggins, I. L. in Amer. Fern Jour. 22:15. 1932.

gravelly soil, less often in shaded or moist situations or in clay soil; it occurs from about sea level up to 2000 m.

California and Baja California.

Representative specimens:

UNITED STATES. CALIFORNIA: *Abrams 3126* (GH, MO, NY), *3402* (F, GH, MO, NY, US); Lt. Whipple's Exped., March 16, 1854, *Bigelow* (GH, NY, US, YU); *Clokey 5165* (F, GH, NY); *Coville & Funston 101* (GH, NY, US); *Fosberg 697* (F, MO, NY, US); *Heller 7276* (GH, MO, NY, US), *7610* (F, GH, MO, NY, US), *8604* (F, GH, MO, NY, US); April 3, 1893, *Henshaw* (NY, US); *Moxley 876* (F, GH, NY, US); *E. Palmer 434* in 1875 (F, MO, NY); *Parish & Parish 671* (F, NY); *R. M. & A. F. Tryon 5053* (BM, MO, NY, P), *5054* (F, K, MO, UC), *5056* (B, GH, MO, US); Jan. 1889, *Underwood* (NY).

MEXICO. BAJA CALIFORNIA: *Ferris 8470* (NY, US); *Wiggins 4212* (F, GH, NY, US).

3. SELAGINELLA ARENICOLA Underw. in Bull. Torr. Bot. Club 25:541. 1898, based on S. *arenaria* Underw. Map 9.

Rhizomes absent; aerial branches with buds present at their base, which are sometimes elongated to form stolons, strictly erect, ascendent to decumbent at the base. Leaves with the base decurrent, blending into the stem in color or sometimes rather abruptly decurrent on the apical portion of the stem; margins rarely eciliate, usually ciliate, the cilia piliform, about ¼ as long as the width of the blade, less often shorter or dentiform; apex nearly flat to carinate; setae usually milk-white to tawny and opaque, rarely whitish with a lutescent base and translucent. Megaspores rugose, rugose-reticulate to rugose-tuberculate on the commissural face, less prominently marked to smooth on the outer face, white to pale orange.

The three subspecies differ in characters of essentially specific value but there are too many intermediates to allow them full recognition. These characters are those mentioned in the key to subspecies. In addition, the subspecies also tend to differ in various leaf characters but these are too variable within each subspecies to be of taxonomic value. Ssp. *Riddellii* has the longest leaf-base and ssp. *acanthonota* has the shortest; ssp. *acanthonota* has the longest setae and ssp. *Riddellii* the shortest; ssp. *acanthonota* has the stoutest leafy stem with the most leaves; ssp. *Riddellii* has the most slender stem with the fewest leaves; and ssp. *acanthonota* has the most cilia on a leaf while ssp. *Riddellii* has the fewest. Subspecies *arenicola* occupies an intermediate position in the range of variability of all of these characters.

Subspecies *Riddellii* is evidently the most primitive of the subspecies. The manner of death of the strobilus is the same as that in all other species of the series and its spores are less distinctive. Ssp. *acanthonota,* with aerial rhizophores, is the most advanced. S. *arenicola* differs from S. *rupincola,* the other member of the series that lacks rhizomes, in having the base of the leaves, at least on the basal portions of the stems, decurrent rather than abruptly adnate.

It grows in open habitats or in light shade, in sand or in weathered soil pockets of acidic rocks. It probably has considerable ability as a colonizer; at least I have seen it in Florida growing on the graded sides of relatively recent roads.

North Carolina to Texas.

KEY TO SUBSPECIES

a. Aerial branches erect; all rhizophores subterranean, branched into roots near the base. b.

b. Basal sporophylls of a strobilus die after the leaves beneath the strobilus; outer face of the megaspores usually rugose.................3a. ssp. *Riddellii*, p. 24

b. Basal sporophylls of a strobilus die before the leaves beneath the strobilus; outer face of the megaspores usually smooth................3b. ssp. *arenicola*, p. 26

a. Aerial branches erect to decumbent at the base; all or many of the rhizophores aerial and unbranched toward the base; basal sporophylls of a strobilus die before the leaves beneath the strobilus; outer face of the megaspores usually smooth....................................3c. ssp. *acanthonota*, p. 26

3a. Selaginella arenicola ssp. **Riddellii** (Van Eselt.) Tryon, comb. nov. Map 10.

Selaginella Riddellii Van Eselt. in Contrib. U. S. Nat. Herb. 20:162. 1918. (Holotype: *Thurow 7* US!. Paratypes: *Drummond 352* NY!; *Holmes & Fetherolf* US!; *Jermy 342* MO!, US!; *Lindheimer 76* MO!; *Long* in 1900 NY!, in 1901 NY!; *Plank* on Aug. 10, 1892 NY!, on Aug. 18, 1892 NY!; *Reverchon 1632* MO!, NY!, US!; *Riddell 16* NY!; *Thurow* US!, *8* US!).

Basal buds sometimes elongated to form stolons; aerial branches erect; rhizophores subterranean, branched into roots near their base. Strobilus usually borne on a long leafy branch, often with vegetative apical growth; basal sporophylls dying after the leaves beneath the strobilus. Megaspores with the outer face usually rugose to rugose-reticulate, rarely smooth.

The following material is intermediate between ssp. *Riddellii* and ssp. *arenicola* (Map 10): LOUISIANA: *Dorman* in 1935 (GH, US); *Wherry* in 1937 (US). ALABAMA: *Harper 37* (GH, MO, NY, US), *3116* (MO, NY, US); *Wolf* in 1933 (US); *Leeds* in 1934 (NY); *Gattman* in 1938 (F). GEORGIA: *Harper 1800* (F, GH, MO, NY, US); *Pyron & McVaugh 3051* (US); *Duncan 8683* (MO).

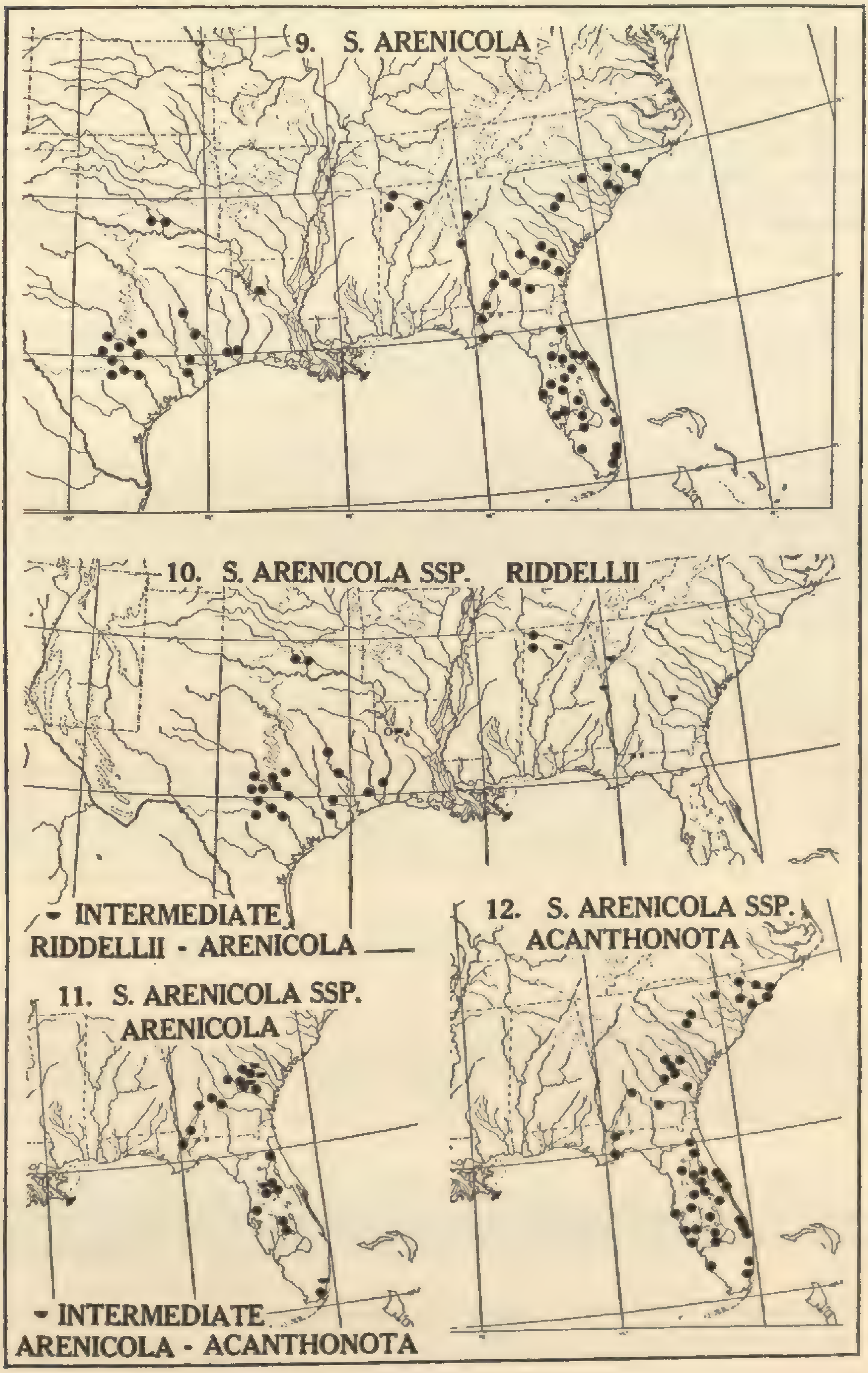
All of the material cited above from Alabama is from Eight-mile Creek and St. Bernard, Cullman Co., and has most of the megasporangia abortive. This is suggestive of hybridization, perhaps with *S. rupestris* which is known from Franklin Co., but it may be due to other causes.

Subspecies *Riddellii* grows in open areas or in open woods, in sand or in crevices or shallow depressions of granite, sandstone or conglomerate outcrops, or at the base of boulders.

Alabama to Oklahoma and Texas.

Representative specimens:

United States. ALABAMA: *Harper 3403* (GH, MO, NY, US), *3762* (GH, MO, NY, US). LOUISIANA: Red River, *Hale* (GH, US). OKLAHOMA: 1928, *Draper & Gould* (US); *Waterfall 6426a* (GH). TEXAS: *Cutler 3220* (GH, MO); *Drummond 352* (GH, NY, US); Jan. 1903, *Holmes & Fetherolf* (US); *Jermy 342* (MO, US); *Lindheimer 76* (GH, MO, US); March, 1900, *W. H. Long* (NY); Feb. 1901, *W. H. Long* (NY); *E. J. Palmer 9540* (MO, US), *13411* (MO, US), *33364* (GH, MO); Aug. 10, 1892, *Plank* (NY); Aug. 18, 1892, *Plank* (NY); *Reverchon 1632* (F, GH, MO, NY, US); *Riddell 16* (NY);


9. S. ARENICOLA
10. S. ARENICOLA SSP. RIDDELLII
▾ INTERMEDIATE
RIDDELLII - ARENICOLA
11. S. ARENICOLA SSP.
ARENICOLA
▾ INTERMEDIATE
ARENICOLA - ACANTHONOTA
12. S. ARENICOLA SSP.
ACANTHONOTA

Oct. 26, 1915, *Thurow* (GH, NY, US); near Prairie View, Waller Co., Jan. 3, 1911, *Thurow 7* (US); *Thurow 8* (US); *R. M. & A. F. Tryon 5030* (B, GH, MO, US), *5033* (BM, F, P, MO, NY, US).

3b. Selaginella arenicola ssp. **arenicola**. Fig. 4. Map 11.

Selaginella arenaria Underw. in Bull. Torr. Bot. Club 25:129. 1898, not *Baker 1883*. (Lectotype: *Underwood 1355* NY! was marked by Maxon as type as to six of the specimens (now marked x); the other specimens and all of those on the sheet of the same collection at US are intermediate between ssp. *arenicola* and ssp. *acanthonota*. Paratypes: *Underwood 1355a* NY!; *Chapman* NY!. *Nash 1449* is excluded as a type, it is ssp. *acanthonota*).

Basal buds not forming stolons; aerial branches erect; rhizophores subterranean, branching into roots near their base. Strobilus usually borne on a long leafy branch, very rarely with vegetative apical growth; basal sporophylls dying before the leaves beneath the strobilus. Megaspores with the outer face smooth to rarely rugose.

Specimens that are intermediate with ssp. *Riddellii* have been mentioned under that subspecies. The following specimens are those intermediate with ssp. *acanthonota* (Map 11): georgia: *Pyron & McVaugh 3101* (MO, US), *3114* (US), *3175a* (US). florida: *A. A. Eaton* in 1903 (US); *Underwood 1355* (NY in part, US).

Subspecies *arenicola* grows in open places among shrubs in white sand or rarely in crevices or on flat exposures of sandstone or granite.

Georgia and Florida.

Representative specimens:

United States. georgia: *A. H. Curtiss 6714* (GH, MO, NY, US); *Harper 1854* (MO, NY, US), *1860* (F, GH, MO, NY, US); *Pyron & McVaugh 3048* (US), *3175* (MO, US); *Tracy 3510* (MO, US). florida: 1840, *Chapman* (NY); July, 1934, *Fennell* (NY, US); *Tryon 5014* (B, BM, GH, MO), *5016* (F, MO, NY, P, US), *5017* (K, MO, UC); Eustis, Lake Co., Jan. 14, 1891, *Underwood 1355* (NY, as to specimens marked x), *1355a* (NY).

3c. Selaginella arenicola ssp. **acanthonota** (Underw.) Tryon, comb. nov. Fig. 5. Map 12.

Selaginella acanthonota Underw. in Torreya 2:172. 1902. (Holotype: *Williamson* NY! fragment US!. Paratype: *Curtis* NY!).

Selaginella rupestris (L.) Spring var. *acanthonota* (Underw.) Clute, Fern Allies, 142, 264. 1905.

Selaginella funiformis Van Eselt. in Proc. Biol. Soc. Wash. 30:161. 1917. (Holotype: *Mohr* US!. Paratypes: *Chapman*, Biltmore Herb. *3432b* US!; *Huger* NY!; *Small & Carter 1013* GH!, NY!; *Small & Wilson 1762* NY!; *Small, Carter & Small 3349* NY!).

Selaginella humifusa Van Eselt. in Contrib. U. S. Nat. Herb. 20:165. 1918, not Hieron. 1911. (Holotype: *Nash 1449* US!. Paratypes: *Eaton* GH!; *Rapp* US!).

Selaginella floridana Maxon in Amer. Fern Jour. 11:1. 1921, based on S. *humifusa* Van Eselt.

Basal buds not forming stolons; aerial branches erect to usually decumbent at the base; rhizophores mostly or entirely aerial and unbranched toward their base. Strobilus borne on a very short to moderately long leafy branch, without vegetative

apical growth; basal sporophylls dying before the leaves beneath the strobilus. Megaspores with the outer face smooth.

Specimens intermediate with ssp. *arenicola* have been discussed under that subspecies. In the several leaf characters mentioned in the discussion of S. *arenicola* the ones characteristic of ssp. *acanthonota* tend to be more distinctive in the northeastern portion of the range, particularly in North Carolina.

Ssp. *acanthonota* grows in open places among shrubs in white sand, rarely on sandstone.

North Carolina to Florida.

Representative specimens:

UNITED STATES. NORTH CAROLINA: *Blake 11481A* (GH, US); *Curtis* (NY); *Heller 14101* (F, MO); Wilmington, July, 1892, *Williamson* (NY, US). SOUTH CAROLINA: *Hermann 10008* (F, GH, MO, NY, US). GEORGIA: *Harper 1852* (F, GH, MO, NY, US), *1957* (F, GH, MO, NY, US), *1987* (GH, MO, NY, US); *Hermann 10128* (F, NY, US); *Tryon 5027* (B, BM, GH, K, MO, P, UC, US). FLORIDA: *Chapman* (Biltmore Herb. 3432b) (GH, NY, US); Nov. & Dec. 1903, *A. A. Eaton* (F, GH); *Foster et al.* (Pl. Exsicc. Gray. 1305) (GH, MO, US); *Harper 10* (F, MO, NY, US), *16* (F, GH, MO, NY, US), *17* (F, MO, NY, US); Jan.-Feb., 1902, *Huger* (NY, US); Carabelle, March 15, 1898, *Mohr* (NY, US); vicinity of Eustis, Lake Co., July 16–31, 1894, *Nash 1449* (F, GH, MO, NY, US); *E. Palmer 660* in 1874 (GH, MO, US); Sept. 1902, S. *Rapp* (NY, US); *Small & Carter 1013* (F, GH, NY, US); *Small, Carter & Small 3349* (NY, US); *Small & Wilson 1762* (NY, US); *Tracy 7554* (F, GH, MO, NY, US); *Tryon 5012* (BM, DS, GH, MIN, MO), *5021* (B, BM, F, GH, K, MO, NY, P, UC, US), *5026* (ARIZ, MICH, MO, RM, US), *5093* (CU, FLAS, MO, PH, POM, US, WS).

4. SELAGINELLA BALANSAE (A. Br.) Hieron. in Hedwigia 39:318. 1900.
Fig. 6. Map 13.

Selaginella rupestris (L.) Spring var. *Balansae* A. Br. in Kuhn, Fil. Afr. 212. 1868, category taken from annotation of type by A. Br. (Holotype: *Balansa* B!. *Peters*, Mozambique, is excluded as a type; it is S. *Dregei*).

Selaginella rupestris ssp. *Balansae* (A. Br.) [incorrectly attributed to Hieron. by] Jahand. & Maire, Cat. Pl. Maroc. 1:11. 1931.

Rhizomes short, creeping; aerial branches with buds present at their base which are sometimes elongated to form stolons, erect or ascendent, rarely some decumbent. Leaves with the base decurrent and blending into the stem in color on the basal portion of the stem, rather abruptly adnate on the apical portion; margins ciliate, the cilia dentiform, about ⅛ or less as long as the width of the blade; apex nearly flat to slightly rounded; setae tawny to whitish, subopaque to translucent. Megaspores rugose on the commissural face, less prominently rugose-reticulate on the outer face, pale yellow to pale orange.

The unusual distribution of the series *Arenicolae* results from the inclusion of this North African species. However, the range of the series is not unlike that of the genus *Platanus*. Superficially S. *Balansae* bears a close resemblance to S. *rupincola* but in technical characters it is probably closest to S. *arenicola*. The localities taken from the literature (Map 13) are from Jahandiez and Maire, Cat. Pl. Maroc. 1:11. 1931.

This species grows in exposed rocky places at 200–1200 m.

Morocco and Spanish Morocco.

Representative specimens:

MOROCCO: Gorges de l'Oued-Ghaghaia, au sud de Maroc, June 3, 1867, *Balansa* (B, K, P, NY, US); *De Retz 31681* (MO); 1908, *Gandoger* (MO); 1935, *Gattefossé* (US); 1871, *Hooker* (NY); *R. Maire 1533* (P).

SPANISH MOROCCO: *Quer 1* (BM).

5. SELAGINELLA WEATHERBIANA Tryon, in Amer. Fern Jour. 40:69. 1950. (Holotype: *Standley 4558* MO!. Paratypes: *Drouet & Richards 3337* MO!; *Ewan 14370* MO!; *Macbride 2651* MO!; *Standley 4158* US!, *4626* MO! NY! US!; *Underwood* NY!; *Underwood & Selby 2* NY!). Figs. 7, 8. Map 14.

Rhizomes widely creeping; aerial branches with buds rarely present at their base, erect or ascendent, rarely some decumbent. Leaves with the base decurrent and blending into the stem in color on the basal portion of the stem, less decurrent, sometimes rather abruptly adnate on the apical portion; margins ciliate, the cilia dentiform, about 1/6 as long as the width of the blade; apex carinate; setae lutescent- to greenish-white, translucent. Megaspores rather coarsely rugose-reticulate, rarely nearly smooth on the outer face, pale yellow to pale orange.

The rhizomes, the strongly carinate leaf-apex and the greenish-white or lutescent setae are characteristic of this species. It often grows in close association with S. *Underwoodii* and, largely on the basis of fragmentary material, was long confused with it.

Selaginella Weatherbiana grows on exposed or shaded rocky hillsides and cliffs, in crevices and on ledges of igneous rock at 2000–3200 m.

Colorado and New Mexico.

Representative specimens:

UNITED STATES. COLORADO: *Ewan 14370* (MO); *Macbride 2651* (MO); *R. M. & A. F. Tryon 5077* (ARIZ, B, BM, CU, DS, F, FI, GH, K, MICH, MIN, MO, NY, P, PH; POM, RM, UC, US, WS); Sept. 1901, *Underwood* (NY); *Underwood & Selby 2* (NY). NEW MEXICO: *Arsène 17817* (US), *17980* (US); *Drouet & Richards 3337* (F, MO); mouth of Indian Creek, San Miguel Co., 8000 ft., July 25, 1908, *Standley 4558* (F, MO, NY, US); *Standley 4158* (US), *4626* (MO, NY, US), *14692* (F, US).

6. SELAGINELLA VIRIDISSIMA Weath. in Jour. Arn. Arb. 24:326. 1943. (Holotype: *Stewart 2204* GH!. Paratype: *Johnston 8683* GH!). Fig. 9. Map 15.

Selaginella Coryi Weath. in Amer. Fern Jour. 36:51. 1946. (Holotype: *Cory 44831* GH! fragment US!).

Rhizomes widely creeping; aerial branches with buds rarely present at their base, erect or ascendent, occasionally some decumbent or prostrate. Leaves with the base decurrent and blending into the stem in color on the basal portion of the stem, less decurrent, essentially distinct in color on the apical portion; margins ciliate, cilia dentiform, 1/8 to 1/6 as long as the width of the blade; apex broadly rounded to carinate, muticous. Megaspores rugose, pale orange.

The muticous leaves afford the best character to distinguish S. *viridissima* from the other species of the series. An additional character is the very slender stems.

From additional material it is evident that *S. Coryi* can not be maintained on the basis of habit; both the Mexican and Texan material have erect or ascendent branches and some prostrate ones in the same mats.

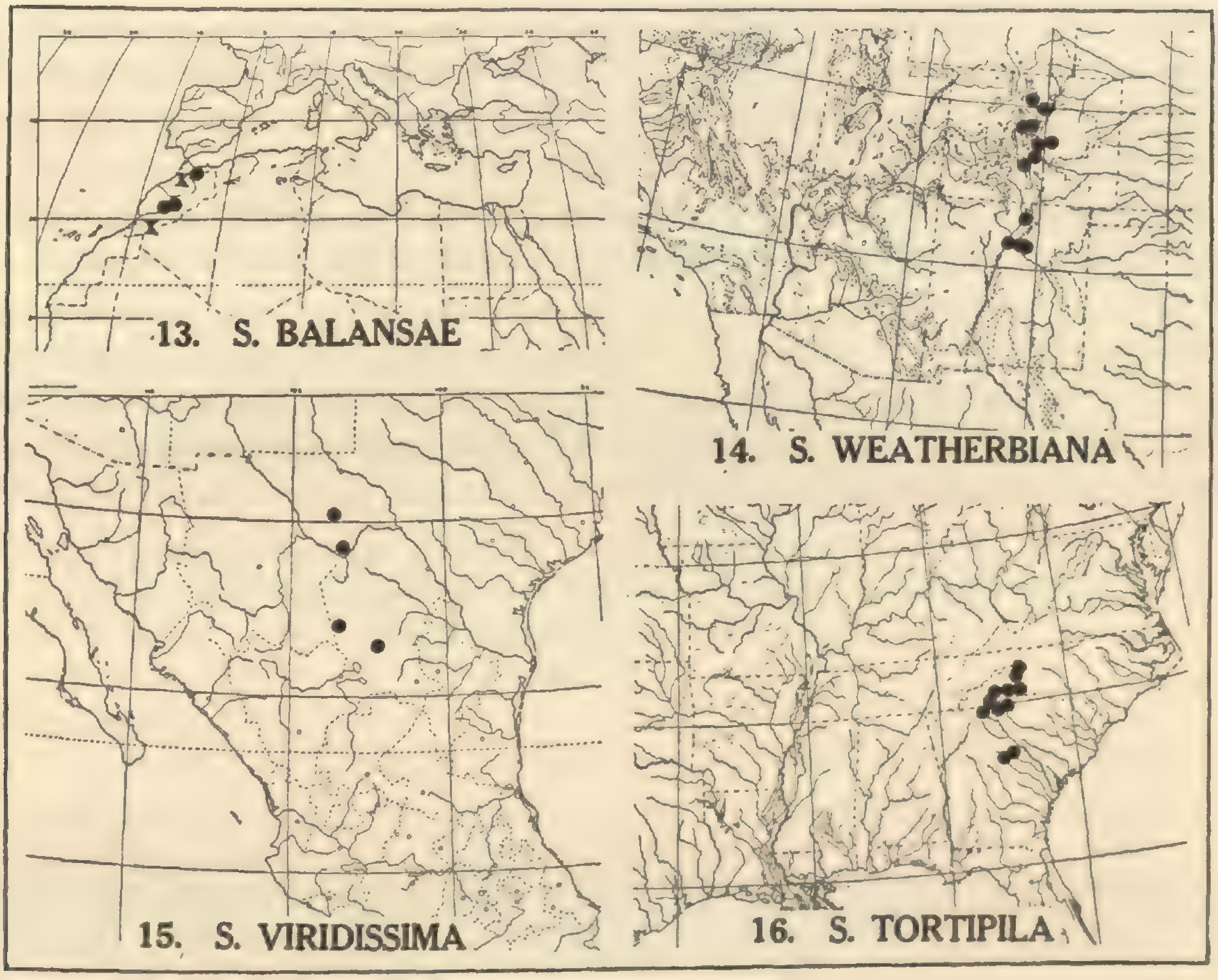
S. viridissima forms large, loose mats, rarely partly pendent, on shaded or locally sheltered cliffs and ledges of igneous rock.

Southwestern Texas and Coahuila.

Specimens examined:

UNITED STATES. TEXAS: *Correll 13627* (MO); Chisos Mountains, Brewster Co., July 10, 1944, *Cory 44831* (GH, US); May 24, 1928, *Murray* (F); *R. M. & A. F. Tryon 5015* (ARIZ, B, BM, DS, F, FI, GH, K, MICH, MO, NY, P, PH, RM, UC, US); *Warnock 21694* (US).

MEXICO. COAHUILA: *Johnston 8683* (GH); *Kenoyer & Crum 2620* (GH); Cañon de Calabasa, north wall of Sierra Maja, Oct. 27, 1941, *Stewart 2204* (GH).



7. SELAGINELLA TORTIPILA A. Br. in Ann. Sci. Nat. V. 3:271. 1865. (Lectotype: *Rugel* B!. Paratype: *Curtis* B!). Fig. 10. Map 16.

Selaginella rupestris (L.) Spring var. *tortipila* (A. Br.) Underw. Our Nat. Ferns, ed. 3, 140. 1888.

Selaginella Sherwoodii Underw. in Torreya 2:172. 1902. (Lectotype: *Sherwood* in 1902 NY!. Paratypes: *Donnell-Smith* in 1882 NY!; comm. *Sherwood* in April, 1902 NY!; *Sherwood* in 1901 NY!. *Donnell-Smith* in 1881 NY! is excluded as a type, it corresponds to the type of *S. tortipila*).

Selaginella rupestris var. *Sherwoodii* (Underw.) Clute, Fern Allies, 142. 1905.

Rhizomes widely creeping; aerial branches with buds sometimes present at their base, erect or ascendent, occasionally some decumbent. Leaves with the base decurrent and blending into the stem in color; dorsal groove absent or developed only in the mid-portion of the blade; margins eciliate to ciliate, the cilia dentiform to piliform, up to ⅙ as long as the width of the blade; apex carinate to strongly carinate; setae with a filiform, tortuous to irregularly flexuous, often deciduous, tip, rarely lacking a modified tip, lutescent- to greenish-white, translucent to subopaque. Megaspores rugose to tuberculate, rarely smooth on the outer face, pale yellow to pale orange.

The two distinctive characters of S. *tortipila,* the poorly developed dorsal groove and the tortuous, filiform seta tip, are somewhat variable. Rarely on some leaves of a stem the dorsal groove may be quite well developed or the setae may be nearly straight and stouter than usual. The strobili are usually very short, about 5 mm. long or less. The basal sporophylls of a strobilus usually die after the leaves beneath; occasionally they die before. S. *arenicola* is the only other species in the series in which the sporophylls die before the leaves beneath the strobilus, this being a character of ssp. *arenicola* and ssp. *acanthonota.*

I am indebted to Dr. A. J. Sharp for adequate collections of this species showing the rhizomes, a character only suggested by the many other collections available.

Wherry[21] pointed out, on the basis of field observation, that specimens described and identified as S. *Sherwoodii* were portions from the center or the upper part of a mat, or from mats growing in unusually exposed situations. The type and similar specimens of S. *tortipila,* on the other hand, represent material from the outer or lower portions of a mat or from a mat growing in a shaded place.

S. *tortipila* usually forms large, compact mats on exposed granite or granite-gneiss cliffs or rocks; less often in thin soil in depressions of rocks or in shaded localities. It grows from 900–1500 m. in North Carolina to as low as 90 m. in Georgia.

North Carolina to Georgia.

Representative specimens:

United States. north carolina: *D. S. & H. B. Correll 7897* (GH, US); 1882, *Donnell-Smith* (GH, MO, NY, US); 1898, *Huger* (B, NY); *Hunnewell 9478* (GH, US), *9479* (GH, US); *Oosting 3640* (MO); Broad River,[22] July, 1841, *Rugel* (B, NY, US); Highlands, Macon Co., 1902, *Sherwood* (NY); April, 1902, comm. *Sherwood* (NY). south carolina: *Curtis* (B); 1881, *Donnell-Smith* (F, GH, MO, NY, US). georgia: *Duncan et al. 9084* (GH, MO); *Hermann 10108* (F, GH, MO, NY, US); *Pyron & McVaugh 2056* (US).

---

[21] Jour. South. Appalach. Bot. Club 1:65–69. 1936.

[22] Wherry, E. T. in Jour. South. Appalach. Bot. Club 1:68. 1936, says that this species grows along the Broad River only at Chimney Rock, Rutherford Co. Presumably Rugel made his collection there.

SERIES **Sartorii** Tryon, ser. nov.

Rhizomata et stolones nulla, gemmae breves simplices ad bases caulium rare praesentes vel absentes. Caules prostrati vel ramis rare ascendentibus vel erectis. Apices ramorum recti vel involuti statu inerte. Caules frondosi valde dorsiventrales vel radialiter symmetricales. Folia base abrupte adnata cum caule distincta colore vel folia caulium primariorum rare decurrentia. Typus: *Selaginella Sartorii* Hieron.

Plants terrestrial or, in S. *extensa,* sometimes epiphytic; rhizomes and stolons absent; short, simple, basal buds present only in S. *Dregei,* and then rarely. Stems prostrate with rhizophores produced generally throughout or, in S. *Dregei,* often irregularly ascendent, or in S. *proxima* and S. *Wightii* the primary branches tending to be erect or ascendent and dendroid with rhizophores few or absent among the branches; stems moderately long to long, or in S. *macrathera* and S. *carinata,* short, or in S. *extensa,* very long; usually forming loose, open, less often compact mats. Branches long to short, remote to approximate, usually intricate; branch tips straight or, in the dorsiventral species, involute in the dormant state; the older primary branches of the main stem (excluding dichotomous branches) once to three, rarely four times pinnate. Leafy stems radially symmetrical, the leaves equal in length, shape, position and texture on all sides of the same portion of the stem, to strongly dorsiventral with the under leaves appressed, the upper erect, the under longer than the upper and different in shape and texture; zone of green leaves equal on all sides of the stem to much longer on the upper side in the dorsiventral species. Leaves with the base abruptly adnate, distinct from the stem in color, or those on the main stems slightly decurrent; apical portion plane or incurved or, in S. *extensa,* revolute; setae straight or nearly so, or in S. *Dregei* and S. *proxima,* strongly curved, entire, or in the upper leaves of S. *echinata,* stellate or substellate. Strobilus with the sporophylls in four ranks, radially symmetrical or dorsiventral, those on the under side longer and broader than those on the upper side or, in S. *Dregei,* with the sporophylls in two ranks on the under side of the branch tip.

This is the most heterogeneous series consisting of three species groups that in a more elaborate classification might be given formal recognition. The least specialized and presumably most primitive group, S. *Sellowii* to S. *extensa,* has the leafy stems and strobili radially symmetrical. The first three species, S. *Sellowii,* S. *Sartorii* and S. *Wightii,* are quite generalized in their characters, the others are specialized in one or more ways. The next group, S. *Wrightii* to S. *indica,* has dorsiventral leafy stems and radially symmetrical strobili. All of the species are specialized in some character. The last and most marked group, S. *njamnjamensis* to S. *Dregei,* has the leafy stems radially symmetrical or dorsiventral and the strobili dorsiventral. These are probably the most highly evolved species in the section and among them S. *echinata* of Madagascar stands as the most specialized. The character of the dorsiventral strobilus has been observed very rarely in S. *mutica* of this series and in S. *Parishii* in *Eremophilae.*

Nearly all of the species of the series are quite distinctive and many of them are exceptionally so. The few close relations that afford a critical separation are S. *Sellowii* and S. *Sartorii*, S. *njamnjamensis* and S. *caffrorum* and perhaps S. *cinerascens* and S. *Arsenei*.

The following specimen may represent a new species of the *Sartorii* but the material is sterile and thus inadequate: M'pala ad litt. occid. lacus Tanganyika, 1898, *Rev. Guillemé 8* (P). It may be a variant of S. *Wightii* var. *Phillipsiana* to which it is evidently related. Its most distinctive character is the margin of the leaf that is smooth or bears a few minute, dentiform cilia. An annotation label by Hieronymus notes it as a new species bearing the name of the collector.

KEY TO SPECIES

a. Sporophylls in four ranks, the strobilus radially symmetrical. New World, Asia, 1 species in eastern Africa. b.

- b. Leafy stems radially symmetrical or nearly so, *or* dorsiventral only in the position of the leaves, the upper and under leaves equal in length and shape or very nearly so on the same portion of the stem. c.
  - c. Apical portion of leaves essentially plane or incurved. d.
    - d. Apex of the blade plane or gently beveled in profile, flat to rounded. e.
      - e. Cilia, especially of the leaves of the main stems, piliform, or dentiform only toward the apex of the blade; *or* if all cilia dentiform then the setae milk-white, opaque; *or* leaves eciliate. f.
        - f. Leaves definitely setate. g.
          - g. Older primary branches once to rarely twice pinnate; apex of the leaves usually convexly acute to acuminate. New World. h.
            - h. Leaf-bases glabrous; setae usually milk-white, opaque, if whitish to greenish-lutescent and subtranslucent (Brazil) then slightly attenuate. Mexico, Cuba, Venezuela to Argentina and Brazil .... 8. S. *Sellowii*, p. 34
            - h. Leaf-bases predominantly pubescent, or if rarely mostly glabrous then the setae strongly attenuate; setae whitish to greenish to lutescent, translucent to subopaque. Mexico, Colombia and Venezuela .... 9. S. *Sartorii*, p. 36
          - g. Older primary branches twice to three times pinnate; apex of the blade long-acuminate. India and Africa .... 10. S. *Wightii*, p. 39
        - f. Leaves, especially of the growing tips of the secondary branches, muticous or with a slightly modified apex. Southern California and Baja California .... 11. S. *cinerascens*, p. 40
      - e. Cilia of the leaves dentiform; setae whitish or greenish- to lutescent-whitish, translucent to subopaque. Mexico. i.

i. Setae about 1/5 or less as long as the blade........12. *S. Arsenei,* p. 41
i. Setae 3/5 to usually 2/3 as long as the blade...13. *S. macrathera,* p. 41
d. Apex of the blade predominantly truncate to abruptly beveled in profile, especially those of the growing-tips, broadly rounded to carinate. j.
j. Apex of the sporophylls carinate; leafy stem somewhat dorsiventral in the position of the leaves. Japan. 14. *S. shakotanensis,* p. 43
j. Apex of the sporophylls rounded to broadly rounded, *or* if carinate then the leafy stem quite or essentially radially symmetrical. k.
k. Leaves ligulate to ligulate-long-triangular, definitely setate. Montana to British Columbia and California...15. *S. Wallacei,* p. 43
k. Leaves oblong- to ovate-lanceolate, muticous or nearly so in Colorado and Utah, setate southward................16. *S. mutica,* p. 44
c. Apical portion of many leaves revolute. Mexico........17. *S. extensa,* p. 47
b. Leafy stems strongly dorsiventral, the under leaves with the blade definitely longer than the upper on the same portion of the stem, or different in shape, or in both length and shape. l.
l. Sporophylls long-ciliate toward the base; under leaves linear; setae arising very evenly in form and usually in color from the blade-apex or the leaves muticous..18. *S. Wrightii,* p. 48
l. Sporophylls eciliate to short-ciliate toward the base. m.
m. Setae arising rather abruptly in form and color from the blade-apex. New World. n.
n. Apex of the blade flat to rounded; some red leaves usually present, especially among the under ones. o.
o. Apex of the blade of the upper leaves long-acuminate; under leaves papyraceous. Guatemala and adjacent Mexico...19. *S. Steyermarkii,* p. 49
o. Apex of the blade of the upper leaves acute to convexly acute; under leaves herbaceous. California..............20. *S. Hansenii,* p. 49
n. Apex of the blade carinate; no red leaves present. Ecuador ....21. *S. carinata,* p. 50
m. Setae arising evenly in form and usually also in color from the blade-apex; under leaves papyraceous. India............22. *S. indica,* p. 52
a. Sporophylls in two ranks, or in four ranks and the strobilus dorsiventral, the sporophylls of the under side longer and broader than those of the upper side. Africa and Madagascar. p.
p. Sporophylls in four ranks; longest cilia of the leaves up to 1/2 as long as the width of the blade. q.
q. Setae whitish to tawny or lutescent, entire. Africa. r.

r. Under leaves herbaceous, the base abruptly adnate, distinct from the stem in color; setae poorly differentiated from the blade-apex in form and color .... 23. S. *njamnjamensis*, p. 52

r. Under leaves papyraceous to papyraceous-herbaceous, the base often decurrent, blending into the stem in color on the main stem; setae predominantly whitish, rather abruptly distinct from the blade-apex in form and color .... 24. S. *caffrorum*, p. 53

q. Setae milk-white, opaque, entire, *or* those of the upper leaves, especially at the branch-tip, whitish, substellate, soon deciduous. Madagascar. s.

s. Setae of upper leaves substellate, soon deciduous .. 25. S. *echinata*, p. 54

s. Setae entire, persistent. t.

t. Setae straight, ¼ to ⅓ as long as the blade .... 26. S. *nivea*, p. 55

t. Setae strongly curved, ⅓ to ½ as long as the blade .... 27. S. *proxima*, p. 56

p. Sporophylls in two ranks; longest cilia of the leaves ½ as long to as long as the width of the blade; setae usually strongly curved. Africa .... 28. S. *Dregei*, p. 57

8. Selaginella Sellowii Hieron. in Hedwigia 39:306. 1900, maintained over S. *Arechavaletae* and S. *montevideensis* by Alston, in Physis 15:252. 1939. (Lectotype: *Sellow* in 1821 B! fragment NY!; *Ule 232* US is nearly identical. Paratypes: *De Moura 908* B; Rio de Janeiro, *Gaudichaud* B; *Riedel 7* B; *Schwacke 949* B; *Lhotzky 7* B). Fig. 11. Map 17.

Selaginella rupestris (L.) Spring f. *amazonica* Milde, Fil. Europ. Atlant. 263. 1867. Holotype: *Humboldt & Bonpland* B!; Peru, Galathea Exped. US 619317 is an excellent match).

Selaginella rupestris f. *brasiliensis* Milde, Fil. Europ. Atlant. 263. 1867. (Lectotype: *Sellow* in 1821 B! fragment NY!. Paratype: *Sellow* B! fragment NY!. *Moritz 370* B! is excluded as a type, it is S. *Sartorii*).

Selaginella rupestris var. *brasiliensis* (Milde) Hieron. in Engl. Bot. Jahrb. 22:417. 1896, not S. *brasiliensis* (Raddi) A. Br. 1865.

Selaginella montevideensis Hieron. in Hedwigia 39:309. 1900. (Lectotype: *Sellow 670* B! fragment NY!; *Gibert 1323* has been annotated at NY as a close match. Paratype: *Gaudichaud* B!).

Selaginella amazonica (Milde) Hieron. in Hedwigia 39:310. 1900, not S. *amazonica* Spring, 1840.

Selaginella Arechavaletae Hieron. in Hedwigia 39:311. 1900. (Holotype: *Arechavaleta 472* B! fragment NY!; *Herter*, Pl. Urug. 2077 is a close match).

Selaginella Mildei Hieron. in Engl. & Prantl, Nat. Pflanz. 1^4:671. 1901, based on S. *amazonica* (Milde) Hieron.

Selaginella pauciciliata Hieron. in Hedwigia 58:284. 1916. (Holotype: *Wright 1820* B!, *Wright '20'* cited by Hieron. is actually *1820* as indicated by an extra label on the sheet at GH).

Stems with the older primary branches once to rarely twice pinnate; leafy stems radially symmetrical to rarely somewhat dorsiventral in position, length and shape of the upper and under leaves. Leaves herbaceous, none red, subulate-long-

triangular to broadly ligulate to lanceolate; base abruptly adnate, distinct from the stem in color or sometimes rather decurrent on the leader stem, glabrous; margins eciliate or usually ciliate, the cilia usually piliform, dentiform only at the apex of the blade, occasionally all dentiform, the longest cilia about 1/5 to rarely 1/2 as long as the width of the blade; apex usually acute to convexly acute, sometimes acuminate, slightly to definitely rounded, plane to rather abruptly beveled in profile; setae arising evenly or abruptly in form and color, 1/4 to nearly 1/2 as long as the blade, slightly attenuate, milk-white and opaque to greenish- or whitish-lutescent and subopaque to translucent. Sporophylls with the margins eciliate to moderately long-ciliate toward the base; apex rounded. Megaspores rugose to rugose-reticulate on the commissural face, rugose-reticulate to smooth on the outer face, yellow to orange-yellow.

This species and the next, S. *Sartorii,* are not well separated by distinctive morphological characters although in the regions where they both occur, Mexico, Colombia and Venezuela, the distinctions are adequate. Each is sufficiently variable, however, so that they overlap in the total range of variation of the characters. I would regard the two as something more than subspecies and yet less than species as judged by the attributes of the other species of the series. However, since they are clearly separable it seems best to give them specific status. S. *Sellowii* is characterized by glabrous leaf-bases and milk-white, opaque setae, while S. *Sartorii* has pubescent leaf-bases and whitish to greenish-lutescent and translucent to subopaque setae. Some Brazilian material of S. *Sellowii* is exceptional in having setae characters like S. *Sartorii* and rarely some Mexican material of S. *Sartorii* will have glabrous leaf-bases.

S. *Sellowii* is composed of three major variants all of which intergrade rather freely. The value of the characters and particularly their degree of correlation is less than in S. *mutica,* for example, where varieties are maintained. For these reasons, the variants are not accorded a status.

The most common variant has the leafy stem radially symmetrical, the leaves narrowly long-triangular to long-triangular with the apex plane in profile, with few or no cilia and with the setae milk-white and opaque. This ranges from Bahia, Brazil, to Argentina and Bolivia with slight variants extending northward to Mexico and Cuba. The material from Ecuador and northern South America has the leaves piliform-ciliate; that from Mexico and Cuba has the leafy stem more slender. The type specimens of S. *pauciciliata,* S. *Sellowii,* S. *Arechavaletae* and S. *montevideensis* are this variant although those of the last three are somewhat intermediate with the next.

The second variant is usually slightly dorsiventral; the leaves are broadly ligulate to ligulate-lanceolate with the apex slightly beveled in profile, with numerous cilia and with the setae whitish and often subopaque. It grows from Rio Grande do Sul, Brazil, to Argentina and Peru. The type specimen of S. *Mildei* belongs here.

The third variant is similar to the second but the leafy stem is very slender; the leaves are not as broad and the setae are greenish- to whitish-lutescent and translucent to subopaque. It is known from the state of Rio de Janeiro, Brazil, and from Rio La Plata (*Selding*, GH).

It is evident that Hieronymus essentially based S. *Sellowii* on S. *rupestris* f. *brasiliensis*, the epithet *brasiliensis* having been previously used at the specific level. However, he did not do it precisely so I am choosing the same type specimen for both names. This species and S. *Sartorii* are both quite generalized in their characters and probably represent the basic New World type of this series. The localities taken from the literature (Map 17) are from Alston, in Physis 15:253. 1939.

On exposed or wooded rocky bluffs and cliffs or among stones, less often in sandy or clay soil, usually at about 1000–2000 m. but ranging from sea level to 2700 m.

Central Mexico; Cuba; Venezuela to Colombia, Argentina and eastern Brazil.

Representative specimens:

Cuba: Mayari, Holquin, Aug. 17, 1859, 1860, *C. Wright 1820* (B, GH, K, MO, NY, YU).

Mexico. distrito federal: *Rose & Painter 6835* (US). puebla: *Arsène 891* (US), *10639* (US). veracruz: *Liebmann 2062* (US).

Venezuela: *Tamayo 298* (US).

Colombia: *Lehmann KK97* (US), *BT776* (US).

Ecuador: *Jameson 426* (US); *Sodiro 47/1* (B).

Peru: *Bües 608* (US); *Herrera 3009a* (US); ad ripam fluminis Marañon, *Humboldt & Bonpland* (B).

Bolivia: *Balls 6229* (US); *Eyerdam 25041* (F, GH); *Steinbach 8254* (F, GH, MO), *8574* (F, GH, MO); *R. S. Williams 1400* (US).

Argentina: *Bartlett 20456* (US); *Burkart 809* (GH), *3308* (GH), *7128* (GH), *10113* (MO); *Burkart & Troncoso 11174* (MO); *Lossen 246* (F, MO); *T. Meyer 2227* (GH), *3687* (NY, US); *Schulz 753* (GH); *L. B. Smith 4679* (US); *Venturi 1144* (GH, US), *1866* (GH, US).

Paraguay: *Fiebrig 4907* (GH, US); *Hassler 12535½* (US); *Jorgensen 4073* (F, NY); *Lindman A2319* (US).

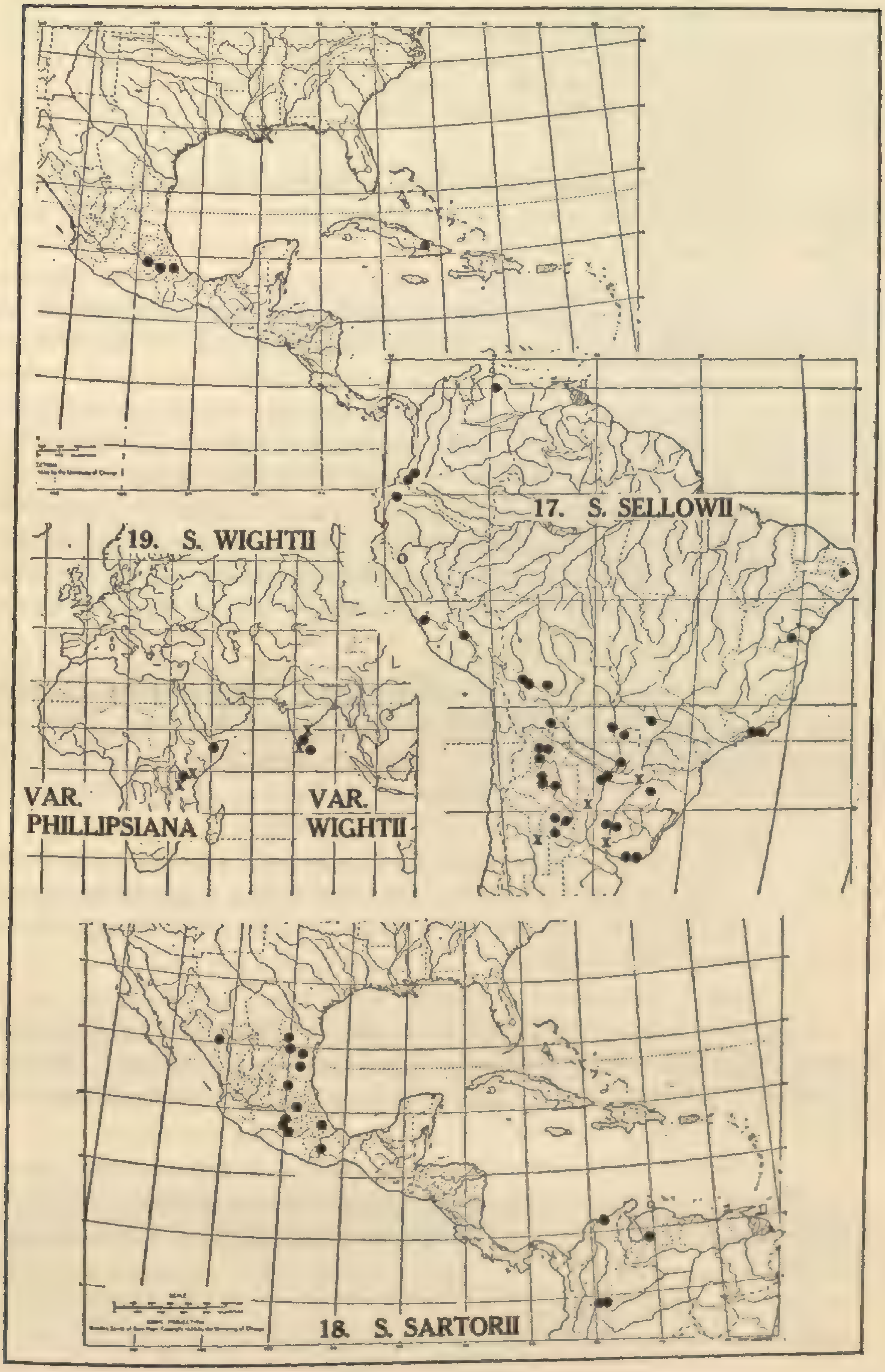
Uruguay: Montevideo, June, 1876, *Arechavaleta 472* (B, K, NY); Montevideo, *Gaudichaud* (B); *Gibert 1323* (NY, US); *Herter 76113* (GH, MO), *78856* (F), *94884* (MO), *99600* (MO); Montevideo, *Sellow 670* (B, K, NY).

Brazil: *Archer & Gehrt 118* (US); *Dusén 14* (US); *Glaziou 3306* (US); *Jürgens 29* (NY), *308* (US), *309* (US); *Lindman A213* (US); *Lützelberg 18870* (NY); *Riedel 7* (GH); *Rose & Russell 19937* (NY, US); *Sellow* (B, NY), Praia de San Diego, 1821, *Sellow* (B, NY); *Ule 232* (US); *Wilkes*, U. S. So. Pacific Expl. Exped. (GH, NY, US, YU); 1934, *S. Wright* (GH).

9. Selaginella Sartorii Hieron. in Hedwigia 39:304. 1900. (Lectotype by Weath. in Jour. Arn. Arb. 25:418. 1944: *Sartorius* B!. Paratypes: *Liebmann* in Aug. 1841 B; *Schiede* in May, 1829 B). Fig. 12. Map 18.

Selaginella Sartorii var. *oregonensis* Hieron. in Hedwigia 39:305. 1900. (Holotype: *"Lyall"* B! fragment NY!, collector and locality unknown).

Selaginella Sartorii var. *venezuelensis* Hieron. in Hedwigia 39:305. 1900. (Holotype: *Moritz 370* B!).


17. S. SELLOWII
19. S. WIGHTII
VAR. PHILLIPSIANA
VAR. WIGHTII
18. S. SARTORII

Selaginella rupestris (L.) Spring var. *Sartorii* (Hieron.) Frye, Ferns Northwest, 31. 1934.
Selaginella porrecta Weath. in Jour. Arn. Arb. 25:416. 1944. (Holotype: *Pennell 17198* US! fragment GH!. Paratypes: *Bartlett 10355* US!, *11039* US!; *Orcutt 1098* US!, *1142* US!, *1151a* US, *5125* US!; *Ortega 5319* US!; *Pennell 17753* US!; *Tharp 1792* US!. *Schaffner 933* YU! is excluded as a type; it is *S. peruviana*).
Selaginella Hintonii Weath. in Jour. Arn. Arb. 25:418. 1944. (Holotype: *Hinton 8423* GH! fragment US!).

Stems with the older primary branches once to rarely twice pinnate; leafy stems radially symmetrical except in the position of the leaves, or very slightly dorsi-ventral in the position and shape of the leaves. Leaves herbaceous to herbaceous-papyraceous, often some red, ligulate to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color or sometimes slightly decurrent on the leader stems, usually pubescent, rarely glabrous; margins ciliate, the cilia piliform, or dentiform only toward the apex of the blade, the longest cilia ¼ to ½ as long as the width of the blade; apex acuminate to convexly acute, flat to slightly rounded, plane to gently beveled in profile; setae arising rather evenly in form but less so in color, ¼ (rarely less) to nearly ½ as long as the blade, slightly to strongly attenuate, whitish to greenish to lutescent, subopaque to translucent. Sporophylls with the margins short- to rather long-ciliate toward the base; apex slightly rounded to carinate. Megaspores prominently and irregularly rugose to rugose-reticulate on the commissural face, more prominently marked to nearly smooth on the outer face, yellow to orange-yellow.

S. *Sartorii* is not strongly separated from S. *Sellowii.* The Venezuelan specimens of S. *Sartorii,* for example, are identified by the pubescent leaf-bases, a character that is usually variable within a species. They also differ from the S. *Sellowii* of that area, however, in the color and opaqueness of the setae. The relations of the two species are discussed in greater detail under S. *Sellowii.*

Some of the Colombian and Venezuelan specimens such as *Lindig 1523, Amórtegui A61* and *Tamayo 1753* have some of the leaves with a rather decurrent leaf-base. *Hinton 3453* (BM) has the leaves almost entirely dentiform-ciliate but otherwise it agrees with S. *Sartorii.*

Like S. *Sellowii,* this species is a complex but it is not as variable nor are the extremes as well marked. I am unable to maintain S. *Hintonii* and S. *porrecta* on the basis of characters of specific value in other species in the series. Without more adequate collections it is not clear whether or not they represent geographic variants.

The type specimen of S. *Sartorii* var. *oregonensis* at Berlin incorrectly bears a Lyall label; the collector and source of the material are not known.

Exposed cliffs and rocky slopes of igneous rock, sandstone or limestone at 870–2000 m.

Mexico, Colombia, Venezuela.

Representative specimens:

MEXICO. TAMAULIPAS: *Bartlett 10355* (US), *11039* (US); *Meyer & Rogers 3112* (MO); *Stanford et al. 2187* (MO). NUEVO LEON: *Orcutt 1098* (US), *1142* (US), *1151a* (US); "Alamar", Pablillo, southeast of Galeana, 1650–1700 m., July 2–3, 1934, *Pennell 17198* (GH, US); *Tharp 1792* (US). SAN LUIS POTOSI: *Orcutt 5125* (US); *Pennell 17753* (US). DURANGO: *Ortega 5319* (US). MEXICO: Ypericones, Temascaltepec, Sept. 7, 1935, *Hinton 8423* (GH, US). VERACRUZ: Mirador, *Sartorius* (B); 1841, *Liebmann* (GH); *Purpus 8463* (GH, MO, US). OAXACA: *Andrieux 2* (GH); *Kenoyer 1566* (GH).

COLOMBIA: *Amórtegui A61* (US); *Lindig 1523* (GH); *Purdie* (YU).

VENEZUELA: Paramo de Mucuchies, *Moritz 370* (B, K, YU); *Tamayo 1753* (US), *1773* (US).

10. SELAGINELLA WIGHTII Hieron. in Hedwigia 39:319. 1900. (Lectotype: *Wight 15* B!. Paratypes: *Walker* B; *Wight 283* B, *3194* B!). Map 19.

Stems with the primary branches tending to be ascendent and dendroid, the older primary branches twice to three times pinnate; leafy stems radially symmetrical or nearly so. Leaves herbaceous to herbaceous-papyraceous, none red, long-triangular to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform, or dentiform toward the apex, the longest cilia ¼ to ½ as long as the width of the blade; apex long-acuminate, flat to slightly rounded, plane to slightly beveled in profile; setae arising evenly in form and often in color, ⅕ to nearly ½ as long as the blade, slightly to strongly attenuate, whitish-lutescent, translucent to subopaque. Sporophylls with the margins eciliate to short-ciliate toward the base; apex broadly rounded to carinate. Megaspores rather finely rugose-reticulate on the commissural face, more coarsely and less prominently marked on the outer face, pale orange-yellow.

S. *Wightii* is the most generalized Old World species in the series and probably represents the basic type for that region as S. *Sellowii* and S. *Sartorii* do for Tropical America. It is most closely related to S. *njamnjamensis*.

The African and Indian plants are very closely related. On the basis of relatively few collections it seems to be distinct but not in characters of specific value. Ample material may indicate a need to change the varietal status given the African plant here.

Southern India and Ceylon, eastern Africa.

KEY TO VARIETIES

a. Setae predominantly strongly attenuate; sporophylls eciliate to only slightly ciliate toward the base .... 10a. var. *Wightii*, p. 39
a. Setae stout to predominantly slightly attenuate; sporophylls predominantly short-ciliate toward the base .... 10b. var. *Phillipsiana*, p. 40

10a. SELAGINELLA WIGHTII var. **Wightii**. Fig. 13. Map 19.

Selaginella Wightii var. *vetusta* Hieron. in Hedwigia 39:320. 1900, ex char. (Holotype: Mauritius, *Sieber* ? B).

The localities taken from the literature (Map 19) are from Alston, in Proc. Nat. Inst. Sci. India 11:215. 1945. Although I have not seen the type of var.

vetusta said, probably in error, to come from Mauritius, the description does not adequately separate it from var. *Wightii.* In addition, I have seen *Gamble 17258* (P) identified by Hieronymus as var. *vetusta* and it is typical var. *Wightii.*

Rocky places, 700–1700 m.

Southern India and Ceylon.

Specimens examined:

India: *Gamble 17258* (P); *Wallich 2188/3* (BM, US); Peninsula Ind. orientalis, *Wight 15* (B, BM, K, P), *Wight 283* (B, K), *3194* (B, GH, K).

Ceylon: *W. Ferguson 233* (US); *Thwaites 1414* (P); *Walker* (GH).

10b. Selaginella Wightii var. Phillipsiana Hieron. in Hedwigia 39:320. 1900. (Holotype: *Phillips* B!).

Selaginella Phillipsiana (Hieron.) Alston, in Jour. Bot. 77:222. 1939.

The localities taken from the literature (Map 19) are from Alston, in Jour. Bot. 77:222. 1939.

On stones and rocks, 1200–1500 m.

British Somaliland to Tanganyika.

Representative specimens:

British Somaliland: *J. B. Gillett 4681* (K), *4681A* (K); *Glover & Gilliland 480* (BM), *771* (BM); *Godman 6* (BM); Darra-as, 5000 ft., June, 1895, *Mrs. Lort Phillips* (B, K, P).

Kenya: *Napier 2054* (K).

Tanganyika: *Uhlig 845* (BM).

11. Selaginella cinerascens A. A. Eaton, in Fern Bull. 7:33. 1899. (Holotype: *Kimball* GH!). Fig. 14. Map 20.

Selaginella bryoides Underw. Our Nat. Ferns, ed. 6, 138. 1900, not (Kaulf.) Hieron., 1901, not *Lycopodium bryoides* Nutt. ex Baker, 1887; considered as based on *Selaginella cinerascens* A. A. Eaton.

Stems with the older primary branches once to usually twice to rarely three times pinnate; leafy stems radially symmetrical or nearly so. Leaves herbaceous to herbaceous-papyraceous, none red, linear, acuminate to broadly lanceolate; base abruptly adnate, distinct from the stem in color or sometimes rather decurrent on the leader stem, usually glabrous, sometimes pubescent; margins rarely eciliate, usually ciliate, the cilia usually piliform, or dentiform only toward the apex, the longest cilia up to ⅓ as long as the width of the blade; apex acute to nearly obtuse, flat to slightly rounded, plane in profile; setae absent, the apex not or slightly modified, or if present, arising rather abruptly in form and color, up to ⅕ as long as the blade, stout, whitish, opaque to translucent. Sporophylls with the margins eciliate to very short-ciliate toward the base; apex broadly rounded to subcarinate. Megaspores slightly rugose on the commissural face, more prominently marked on the outer face, with an equatorial ring, pale yellow.

S. *cinerascens* is quite closely related to the next species, S. *Arsenei*. The two may be distinguished by the cilia which are predominantly piliform in S. *cinerascens* and dentiform in S. *Arsenei*. There is a close resemblance to S. *nivea* of Madagascar but this does not extend beyond characters of habit and general aspect.

This species affords the best illustration of the difference in length of leaves on the stem and branches, a character presumably due to some type of inhibition of growth. The leaves on the main stem are the longest, those on the primary branches are shorter and those on the secondary branches are the shortest.

S. *cinerascens* is one of the few species that is not closely associated with rocky habitats. It grows on hillsides and slopes, among or beneath shrubs and small trees, often in clay soil, sometimes in rocky soil, from sea level to about 200 m.

California and Baja California.

Representative specimens:

UNITED STATES. CALIFORNIA: *Abrams 3399* (F, GH, MO, NY, US); April 12, 1918, *Bethel* (GH, MO, US); National City (San Diego), May, 1897, *L. F. Kimball* (GH, NY); *Parish 10765* (NY, US).

MEXICO. BAJA CALIFORNIA: *Ferris 8474* (NY, US); *Wiggins 4213* (GH, NY, US).

12. SELAGINELLA ARSENEI Weath. in Jour. Arn. Arb. 25:417. 1944. (Holotype: *Arsène 10641* US! fragment GH!. Paratypes: *Arsène 9983* US!, *10643* US!). Fig. 15. Map 21.

Stems with the older primary branches once to twice pinnate; leafy stems radially symmetrical. Leaves herbaceous, none red, ligulate to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color, glabrous to pubescent; margins ciliate, the cilia dentiform, the longest cilia about ⅛ as long as the width of the blade; apex acute to acuminate, rounded, plane or nearly so in profile; setae absent, the apex slightly modified, or if present, arising evenly in form and usually in color, about ⅕ as long as the blade, stout, greenish- to lutescent-whitish, subopaque. Sporophylls with the margins very short-ciliate toward the base; apex broadly rounded. Megaspores slightly and finely rugose-reticulate, lemon-yellow.

The differences between S. *Arsenei* and the closely related S. *cinerascens* are discussed under S. *cinerascens*.

S. *Arsenei* grows in rocky places, at one locality at 2700 m.

Central Mexico.

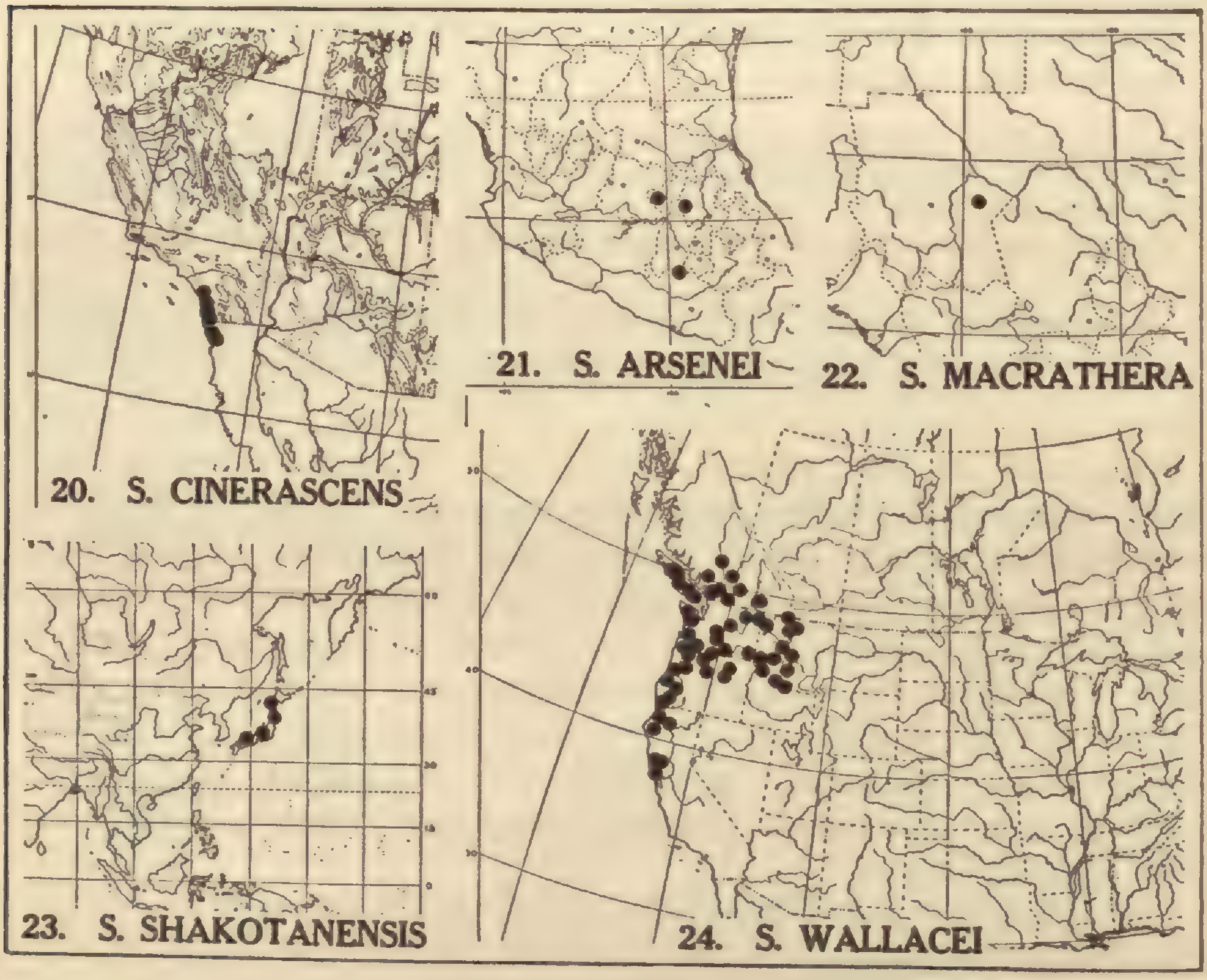
Specimens examined:

MEXICO. SAN LUIS POTOSI: *T. C. & E. M. Frye 2983* (F). QUERÉTARO: Querétaro, 1914, *Arsène 10641* (GH, US), *9983* (US), *10643* (US). HIDALGO: *Hitchcock & Stanford 7248* (US). GUERRERO: *T. C. & E. M. Frye 3149* (US).

13. SELAGINELLA MACRATHERA Weath. in Jour. Arn. Arb. 24:326. 1943. (Holotype: *Johnston 8067* GH!). Fig. 16. Map 22.

Stems short, with the older primary branches once to rarely twice pinnate; leafy stems radially symmetrical. Leaves herbaceous-papyraceous, none red, sub-

ulate; base abruptly adnate, distinct from the stem in color, glabrous to slightly pubescent; margins ciliate, the cilia dentiform, or short-piliform only at the base, the longest cilia 1/4 or less as long as the width of the blade; apex acuminate to bluntly acuminate, broadly rounded, plane or nearly so in profile; setae arising abruptly in form and color, 3/5 to usually 2/3 as long as the blade, filiform, white or whitish, subopaque to translucent. Sporophylls with the margins short-ciliate toward the base; apex broadly rounded to carinate. Megaspores slightly to moderately finely rugose on the commissural face, moderately rugose on the outer face, yellow-orange.



Although known from only a single collection there is no doubt that this is a valid species. The dentiform cilia of the leaves and the very long setae distinguish it from all others.

Collected on ledges on north-facing lava cliffs in Chihuahua, Mexico.

Specimens examined:

Mexico. chihuahua: Sierra del Virulento, 2–3 miles east of Rancho Virulento, ca. 65 miles south of Ojinaga, Aug. 11, 1941, *I. M. Johnston 8067* (GH, MO).

14. SELAGINELLA SHAKOTANENSIS (Franch. ex Takeda) Miyabe & Kudo, in Jour. Fac. Agric. Hokkaido Imp. Univ. 26 (Fl. Hokkaido & Saghal. I):64. 1930. Fig. 17. Map 23.

Selaginella rupestris (L.) Spring var. *shakotanensis* Franch. ex Takeda, in Bot. Mag. Tokyo 23:237. 1909. (Holotype: *Faurie 9895* SAP).

Stems with the older primary branches once to twice pinnate; leafy stems somewhat dorsiventral in the position of the leaves. Leaves fleshy to fleshy herbaceous, none red, ligulate to ligulate-lanceolate; base abruptly adnate, distinct from the stem in color, or sometimes rather decurrent on the leader stems, glabrous; margins ciliate, the cilia piliform, or dentiform only toward the apex, the longest cilia ¼ to ⅓ as long as the width of the blade; apex convexly acute to obtuse, rounded to carinate, abruptly beveled to truncate in profile; setae arising abruptly in form and color, about ⅕ as long as the blade, attenuate, whitish, translucent. Sporophylls with the margins eciliate to long-ciliate toward the base; apex narrowly carinate. Megaspores finely and very slightly rugose-reticulate, orange.

S. *shakotanensis* may be distinguished from S. *sibirica* of *Rupestres*, which overlaps its range, by the shorter setae and the abruptly adnate leaf-bases. The setae are about ⅕ as long as the blade in this species while they are ⅓ as long or longer in S. *sibirica*. The main stem may have some of the leaves with a decurrent base but on the branches the leaf-base is abruptly adnate. S. *shakotanensis* bears a rather close resemblance to S. *mutica* var. *limitanea* from which it may be separated by its slightly dorsiventral leafy stem.

Rocky alpine habitats; one collection was made at 2000 m.

Japan.

Specimens examined:

JAPAN: Aug. 20, 1898, *Faurie* (P), *1577* (P), Shakotan, Yezo Island, Shiribeshi, June 9, 1893, *Faurie 9895* (P, MO), *10543* (P, MO), *13151* (P, MO); U. S. Nat. Herb. sheet 1095388.

15. SELAGINELLA WALLACEI Hieron. in Hedwigia 39:297. 1900, maintained over S. *montanensis* by Broun, Index N. Am. Ferns, 159. 1938. (Holotype: *Wallace* B! fragment NY!). Fig. 18. Map 24.

Selaginella montanensis Hieron. in Hedwigia 39:293. 1900. (Holotype: *A. & A. Krause* B! fragment NY!).

Selaginella rupestris (L.) Spring f. *Wallacei* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Selaginella rupestris f. *montanensis* (Hieron.) Clute, in Fern Bull. 16:52. 1908, as *montaniensis*.

Selaginella rupestris var. *columbiana* M. E. Jones, in Univ. Mont. Bull. Biol. Ser. 15:8. 1910. (Holotype: *M. E. Jones*, Flathead Lake, near Weiser, Idaho).

Selaginella rupestris var. *Wallacei* (Hieron.) Frye, Ferns Northwest, 33. 1934.

Selaginella Rosendahlii Hieron. ex Frye, Ferns Northwest, 33. 1934, in synon. (Evidently based on *Rosendahl 864*).

Selaginella Wallacei f. *columbiana* (M. E. Jones) Broun, Index N. Am. Ferns, 159. 1938.

Selaginella rupestris var. *montanensis* (Hieron.) [incorrectly attributed to Frye by] Broun, Index N. Am. Ferns, 159. 1938, in synon.

Stems with the older primary branches once to twice, rarely three times pinnate; leafy stems radially symmetrical to rather dorsiventral in position, length and shape of the upper and under leaves. Leaves herbaceous to fleshy, none red, ligulate to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color, sometimes rather decurrent on the leader stems, glabrous or pubescent; margins eciliate or ciliate, the cilia dentiform to usually piliform, the longest cilia 1/5 to 1/4 as long as the width of the blade; apex acute to obtuse, broadly rounded, abruptly beveled to truncate in profile, or predominantly so; setae arising abruptly in form and color, 1/5 to 1/4, rarely 1/3, as long as the blade, rather stout, milk-white and opaque to whitish or greenish-white and translucent. Sporophylls with the margins eciliate to short-ciliate toward the base; apex broadly rounded to subcarinate. Megaspores rugose to rugose-reticulate, usually with an equatorial ring, pale orange.

S. *Wallacei* is one of the most variable species in habit and general aspect. It is also, of the species I know sufficiently, the one with the widest range of habitats and to a considerable extent its variability is correlated with its ecology. Specimens from very damp, shady situations have long stems that form loose mats and the leaves are somewhat distant. Those from dry, exposed rock or gravelly turf have short stems that form a compact mat and the leaves are close.

Of the species that grow within its range it sometimes resembles S. *densa* var. *scopulorum* of *Rupestres*. It may be separated by the remote branches, S. *densa* having approximate ones, and by its abruptly adnate rather than decurrent leaf-bases.

Suskdorf 8563 GH has a strobilus 9 cm. long, the longest I have seen in any species.

Selaginella Wallacei grows on dry, exposed cliffs, talus slopes, rocky bluffs and gravelly soil, or on moist, shaded rocks, bluffs and cliffs, in crevices or covering various types of igneous and sedimentary rocks, from sea level to 2000 m.

Western Montana to southern British Columbia and California.

Representative specimens:

Canada. british columbia: *Hitchcock & Martin 7367* (MO, NY); *Macoun 86372* (GH, NY, US), *86376* (GH, NY, US), *86377* (GH, NY, US); *Rosendahl 864* (BM, MIN, MO, NY, US).

United States. montana: Aug. 13, 1908, *M. E. Jones* (BM, MO, US); "Crossing", Northern Pacific Railroad, Oct. 1, 1882, *A. & A. Krause* (B, NY). idaho: *Kirkwood & Severy 1718* (GH, US); *H. T. Rogers 763* (GH, MO); *Sandberg et al. 54* (GH, US). washington: *Constance & Rollins 998* (F, GH, MO, NY, US); *Otis 1149* (GH, MO, NY, US); *Suskdorf 8563* (GH, MO, US); *Thompson 8747* (F, MO, NY); *S. M. & E. B. Zeller 748* (GH, MO, US). oregon: *Thompson 4002* (MO, NY, US), *4029* (MO, NY, US), *4102* (MO, US); Oregon, *Capt. Wallace* (B, NY, YU); *Wilkes Exped.* "Wash. & Ore. Terr." (GH, NY, US, YU). california: *Baker 2746* (GH, NY, US); *Beetle 1566* (GH, MO, NY, US); *Heller 5024* (GH, MO, NY, US).

16. Selaginella mutica D. C. Eaton ex Underw. in Bull. Torr. Bot. Club 25:128. 1898. (Lectotype by Weath. in Jour. Arn. Arb. 25:413. 1944: *Meehan* YU! fragment NY!. Paratypes: *M. A. C. Livermore* NY!; *A. G. Compton* NY!; *E. J. Spence* NY!; *Toumey* on Aug. 28, 1894 NY!; *Brandegee*

NY!. *Bigelow* NY! and *Mex. Bound. Survey* NY! are excluded as types; they are intermediates between var. *limitanea* and var. *mutica*).

Stems with the older primary branches once to twice pinnate; leafy stems radially symmetrical. Leaves fleshy to fleshy-herbaceous, none red, ligulate-lanceolate to lanceolate-elliptical to lanceolate-ovate; base abruptly adnate, distinct from the stem in color, or slightly decurrent on the leader stems, glabrous or pubescent; margins ciliate, the cilia entirely piliform, the longest cilia ¼ to ⅓ as long as the width of the blade, to entirely dentiform and shorter; apex obtuse to convexly acute, strongly carinate, subtruncate in profile; setae absent, the apex being scarcely modified, or if present, arising abruptly in form and usually in color, up to ⅕ as long as the blade, stout, whitish to greenish-white, subopaque to translucent. Sporophylls with the margins eciliate to long-ciliate toward the base; apex carinate to narrowly carinate. Megaspores rugose-reticulate to coarsely rugose on the commissural face, less marked to smooth on the outer face, pale orange.

The variation of *S. mutica,* as pointed out by C. A. Weatherby,[23] is rather parallel to that of *S. Underwoodii* which has a very similar range. However, in *S. mutica* the material of Texas, southern New Mexico and southern Arizona is more distinctive and the line of demarcation stronger than in *S. Underwoodii,* so that I am recognizing two varieties. The characters of seta length and ciliation of the sporophylls correlate to a high degree and separate the major components of the species. The southern var. *limitanea* is itself variable but the extremes, one with short, dentiform, ascending cilia on the leaves, and the other with long, piliform, patent cilia, are too often connected by intermediates and the characters vary considerably in some individual mats.

The muticous incurved leaves of var. *mutica* give the stems a reptilian aspect under low magnification.

In Colorado I have seen *S. mutica* growing with *S. Underwoodii* in the same niche. From a number of such cases it appeared quite clear that although the mats of the two species were originally nearly equal in size, *S. mutica* gradually occupied more and more of the niche and finally entirely replaced *S. Underwoodii.*

Rarely a strobilus may be slightly dorsiventral.

Colorado and Utah to Texas and Arizona.

KEY TO VARIETIES

a. Leaves setate; sporophylls with the cilia mostly or entirely ascending, all or some dentiform............16a. var. *limitanea,* p. 46

a. Leaves muticous or nearly so; sporophylls with the cilia entirely or predominantly spreading, piliform............16b. var. *mutica,* p. 46

[23] Jour. Arn. Arb. 25:415. 1944.

16a. Selaginella mutica var. limitanea Weath. in Jour. Arn. Arb. 25:414. 1944. (Holotype: *Goodding* US! fragment GH!. Paratypes: *Ferriss* GH!; *Hinckley 1155* US!; *Ingram 2723* US!; *Moore & Steyermark 3046*, in part, GH!; *E. J. Palmer 31951* US!; *Slater* US!; *Standley* in 1906 US!; *Wooton* in 1899 US!, in 1903 US!, in 1906 US!, in 1909 US!). Map 25.

Selaginella mutica var. *texana* Weath. in Jour. Arn. Arb. 25:414. 1944. (Holotype: *Moore & Steyermark 3196* GH! fragment US!. Paratypes: *Moore & Steyermark 3046*, in part, GH!; *E. J. Palmer 30871* GH!; *Sperry 428* US!. *Tracy & Earle 275* GH! US! and *Mex. Bound. Survey* YU fragment NY! are excluded as types; they are intermediate between var. *limitanea* and var. *mutica*).

Leaves short-setate; cilia mostly or entirely ascending, piliform to dentiform. Sporophylls with the cilia mostly or entirely ascending, all or some dentiform.

Sheltered or moist cliffs and rocky hillsides, on igneous rocks, 1300–2400 m.

Southwestern Texas to southeastern Arizona.

Representative specimens:

United States. texas: *Hinckley 1155* (GH, US); *Ingram 2723* (US); *Moore & Steyermark 3046* (GH, MO, US); ridge south of Emory Peak, Chisos Mountains, Brewster Co., 2300 m., June 22, 1931, *Moore & Steyermark 3196* (GH, MO, US); *E. J. Palmer 30871* (GH, MO, US), *31951* (MO, US); *Sperry 428* (US). new mexico: mountains south of Deming, Oct. 4, 1937, *Goodding* (GH, US); Dec., 1924, *Slater* (US); Sept. 10, 1899, *Wooton* (US), April 18, 1903 (NY, US), June, 1906 (US), Jan. 9, 1909 (US). arizona: March, 1904, *Ferriss* (GH).

16b. Selaginella mutica var. mutica. Fig. 19. Map 26.

Selaginella Watsonii mutica (D. C. Eaton ex Underw.) Clute, Fern Allies, 144, 264. 1905.

Leaves muticous or nearly so; cilia entirely or predominantly spreading, piliform. Sporophylls with the cilia entirely or predominantly spreading, piliform.

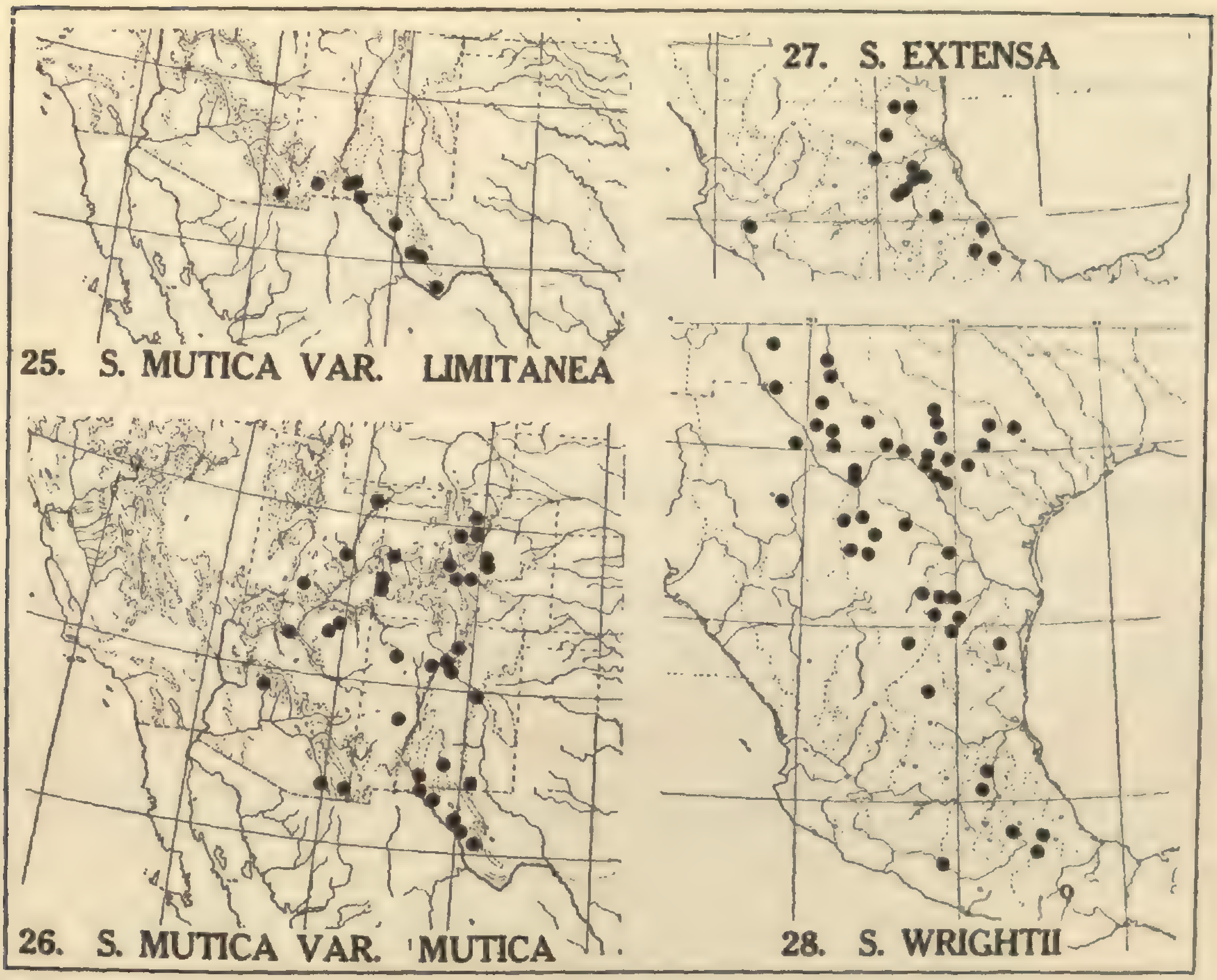
The following specimens are intermediate between var. *mutica* and var. *limitanea: Tracy & Earle 275* (BM, F, GH, MO, NY, US); Mex. Bound. Survey, *Parry et al.* (MO, NY); New Mexico, 1853, *Bigelow* (NY).

Exposed or sheltered rocky bluffs, cliffs and ledges, in crevices or soil pockets or usually covering rocks, on igneous rocks, sandstone or rarely limestone, 1450–4300 m.

Colorado and Utah to Texas and Arizona.

Representative specimens:

United States. colorado: 1874–1878, *Brandegee* (NY); *A. G. Compton* (NY); *I. M. Johnston 2423* (F, GH, NY, US); *M. A. C. Livermore* (NY); mountains of Colorado, 1871, *T. Meehan* (NY, YU); *E. J. Spence* (NY); *R. M. & A. F. Tryon 5071* (CU, MIN, MO, PH, POM, UC, US), *5072* (B, MO, US), *5073* (F, MO, NY, P, UC), *5075* (ARIZ, DS, FI, K, MICH, MO, RM); *E. P. Walker 365* (GH, NY, US). utah: *Graham 7592* (US), *10004* (US); *Maguire 18450* (GH). texas: 1921, *Goodding* (BM, GH, NY, US); *R. M. & A. F. Tryon 5083* (BM, GH, MO, US); *Waterfall 4811* (GH, MO, NY), *5392* (GH, MO, NY); *Wright 2115* (GH, NY). new mexico: *Arsène & Benedict 16643* (F, US); *Drouet & Richards 3311* (F, GH, MO, NY, US); *Standley 5199* (MO, NY, US). arizona: *Darrow 3631* (GH); 1896, *Toumey* (NY, US), 1894, *Toumey* (NY).



17. SELAGINELLA EXTENSA Underw. in Bull. Torr. Bot. Club 25:131. 1898. (Holotype: *Pringle 3900* NY. Paratype: *C. Müller* NY). Fig. 20. Map 27.

Selaginella rupestris mexicana Conzatti, Fl. Tax. Mex. 1:150. 1939, without Latin description, not var. *mexicana* Milde, 1867. (Based on *Pringle 3900*).

Plant terrestrial or sometimes epiphytic. Stems very long to long, branches long, remote, with the older primary branches once to twice pinnate; leafy stems radially symmetrical or nearly so. Leaves herbaceous, none red, subulate to ligulate-long-triangular to ligulate-lanceolate; base abruptly adnate, distinct from the stem in color, usually glabrous, sometimes pubescent; margins ciliate, the cilia dentiform, the longest cilia less than ¼ as long as the width of the blade; apical portion usually revolute; apex acuminate, rounded, plane or nearly so in profile; muticous, the apex subulate, greenish-hyaline. Sporophylls with the margins eciliate to short-ciliate toward the base; apex carinate. Megaspores finely rugose-reticulate on the commissural face, the equatorial region strongly and irregularly papillate, granular on the outer face, pale orange.

S. *extensa* is casually epiphytic and rather similar in habit to the pronounced epiphyte S. *oregana* of *Rupestres.* The revolute apical portion of many of the leaves, the muticous essentially unmodified leaf-apex, the habit and the unusual papillate megaspores combine to make this a very distinctive species.

On cliffs or in woods, covering limestone rocks or pendent from tree trunks, 870–1700 m.

Eastern Mexico and Jalisco.

Specimens examined:

Mexico. tamaulipas: *Sharp et al. 50255* (MO, US). san luis potosi: *McVaugh 10446* (US); *Pennell 17947* (US); Las Canoas, Aug. 21, 1891, *Pringle 3900* (F, GH, K, MO, US); *Sharp 46264* (US). veracruz: *Bourgeau 2541* (GH, YU); *Mohr 12* (YU); *Purpus 6052* (F, GH, MO, US); *Sharp 44168* (US). hidalgo: *T. C. & E. M. Frye 2537* (NY, US); *Hoogstraal & Chase 7308* (F, MO, US); *Kenoyer & Crum 3910* (GH); *Sharp 45864* (US). puebla: *Sharp 45375* (US). jalisco: *McVaugh 11829* (US).

18. Selaginella Wrightii Hieron. in Hedwigia 39:298. 1900. (Holotype: *Wright 828* B!). Fig. 21. Map 28.

Selaginella rupestris (L.) Spring f. *Wrightii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Stems with the older primary branches once to twice pinnate; leafy stems usually strongly to rarely moderately dorsiventral in position, length and shape of the upper and under leaves. Upper leaves ligulate-long-triangular to long-triangular; apex acuminate to convexly acute. Under leaves herbaceous, none red, longer to only slightly longer than the upper, linear; apex acuminate, flat to slightly rounded, plane or nearly so in profile. All leaves with the base abruptly adnate, distinct from the stem in color, or the under leaves with the base rather decurrent, pubescent or glabrous; margins ciliate, the cilia piliform, or dentiform only toward the apex, the longest cilia ⅓ to ½ as long as the width of the blade; setae absent, the apex being hardly modified, or if present, arising very evenly in form and usually in color, rarely up to ⅓ as long as the blade, stout, whitish-lutescent to lutescent, translucent to opaque. Sporophylls with the margins long-ciliate toward the base; apex broadly rounded to carinate. Megaspores prominently rugose, pale to bright orange.

Of the definitely dorsiventral species of the series, S. *Wrightii* is the least dorsiventral. The linear under leaves, the long-ciliate sporophylls and the poorly differentiated setae are the primary characters of the species. This is the only species for which I have sufficient information to class definitely as a calciphile.

Exposed or shaded ledges and pockets of limestone, 800–2300 m.

Texas and New Mexico to southern Mexico.

Representative specimens:

United States. texas: *E. J. Palmer 11389* (GH, MO, NY, US); *Rose & Fitch 17973* (MO, NY, US); *Tharp 43-514* (MO, NY, US); *R. M. & A. F. Tryon 5034* (BM, GH, MO, P, US), *5035* (B, BM, F, GH, MO, NY, P, UC, US), *5037* (ARIZ, FI, GH, K, MO, RM, US); hills, Turkey Creek (near Cline, Uvalde Co.), June 25, 1849, *Wright 828* (B, GH, NY, US). new mexico: *Standley 40389* (GH, US).

Mexico. tamaulipas: *Bartlett 10561* (F, US). nuevo leon: *Barkley 16144M* (GH, MO); *Harvey 988* (GH, US); *C. H. Muller 2638* (GH, US). coahuila: *Johnston 8607* (GH, MO), *8854* (GH), *9106* (GH, MO, US). chihuahua: *Harvey 1507* (GH, US); *E. Palmer 455* in 1885 (GH, US, YU). san luis potosi: *A. A. Lundell 96* (US). zacatecas: *Lloyd & Kirkwood* (or *Kirkwood*) *20* (MO, US), *142* (GH, MO). hidalgo: *Kenoyer 1053* (GH). puebla: *E. B. Copeland 174* (US). guerrero: *Hinton 9678* (GH, US). oaxaca: *Pringle & Conzatti 1390* (GH).

19. SELAGINELLA STEYERMARKII Alston, in Ann. & Mag. Nat. Hist., XII, 7:638. 1954. (Holotype: *Steyermark 50501* BM!. Paratypes: *Steyermark 47115* BM!, *51292* BM!). Figs. 22, 23. Map 29.

Stems with the older primary branches once to twice pinnate; leafy stems strongly dorsiventral in position, length and shape of the upper and under leaves. Upper leaves subulate to subulate-long-triangular; apex long-acuminate. Under leaves papyraceous to herbaceous-papyraceous, usually some red, longer than the upper, subulate-lanceolate to ligulate-lanceolate; apex long-acuminate, flat or very slightly rounded, plane in profile. All leaves with the base abruptly adnate, distinct from the stem in color, pubescent to rarely glabrous; margins ciliate, cilia piliform, the longest cilia ¼ to ½ as long as the width of the blade; setae usually arising evenly in form and abruptly in color, ¼ to ⅓ as long as the blade, slightly to strongly attenuate, white to whitish-lutescent, translucent to subopaque. Sporophylls with the margins eciliate to short-ciliate toward the base; apex rounded to carinate. Megaspores finely to moderately rugose-reticulate, to nearly smooth on the outer face, more prominently and coarsely marked in the equatorial region, pale orange.

This species and the next, *S. Hansenii,* are the only ones that usually have some red leaves on the stem. In *S. Sartorii* such leaves are present infrequently. They tend to occur particularly among the oldest living leaves and the youngest dead ones and often are more common on the under side of the stem.

The long-acuminate apex of the upper leaves and the thin under leaves afford an ample separation from *S. Hansenii.* This species has the most robust leafy stems of any in the series and material collected in the growing state presents particularly attractive sprays. It is one of the very few species I know to be casually cultivated; the Standley collection cited below was from the garden of Mariano Pacheco.

Rocks and banks, 1630–2000 m.

Guatemala and adjacent Mexico.

Specimens examined:

MEXICO. CHIAPAS: *Matuda 1846* (US).

GUATEMALA: *Aguilar 1429* (F, US); *Hatch & Wilson 283* (US), *325* (US); *Haupt 105* (US); *Maxon & Hay 3410* (US); *Standley 63102* (F, US); *Steyermark 47115* (BM), between San Sebastián Hacienda and large peñasco above town, Dept. Huehuetenango, 2000–2200 m., 1942, *Steyermark 50501* (BM), *Steyermark 51292* (BM); *Tuerckheim 8844* (GH, US); *L. O. Williams 14299* (US).

20. SELAGINELLA HANSENII Hieron. in Hedwigia 39:301. 1900, as *Hanseni;* maintained over *S. Bolanderi.* (Lectotype: *Hansen 878* B!. Paratypes: *Hillebrand* B!; *A. A. Eaton* B!). Fig. 24. Map 30.

Selaginella Bolanderi Hieron. in Hedwigia 39:300. 1900. (Holotype: *Bolander 4511* B! fragment NY!).

Selaginella rupestris (L.) Spring f. *Hansenii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Selaginella rupestris f. *Bolanderi* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Selaginella rupestris var. *Hansenii* (Hieron.) Jepson, Man. Pl. Calif. 42. 1923.

Selaginella rupestris var. *Bolanderi* (Hieron.) Jepson, Man. Pl. Calif. 42. 1923.

Stems with the older primary branches once to usually twice to rarely three times pinnate; leafy stems strongly dorsiventral in position, length and shape of the upper and under leaves. Upper leaves long-triangular to ligulate to lanceolate-long-triangular; apex convexly acute to acute. Under leaves herbaceous, usually some red, longer than the upper, linear-lanceolate to lanceolate; apex convexly acute to acuminate, flat to slightly rounded, plane to gently beveled in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous or pubescent; margins ciliate, the cilia piliform, or dentiform only toward the apex, the longest cilia ¼ to rarely nearly ½ as long as the width of the blade; setae arising rather abruptly in form and in color, ⅕ to nearly ½ as long as the blade, stout to attenuate, milk-white to whitish, translucent to opaque. Sporophylls with the margins eciliate to short-ciliate toward the base; apex broadly rounded to carinate. Megaspores rugose to rugose-reticulate on the commissural face, less prominently rugose-reticulate to smooth on the outer face, with an equatorial ring, lemon-yellow.

S. *Hansenii* is related to the previous species, S. *Steyermarkii*, by the dorsiventral leafy stem and the commonly occurring red leaves. These characters, however, may be the result of parallel evolution. The red leaves tend to be more common on the under side of the stem and in the area where living and dead leaves adjoin.

The branches at the center of a mat tend to be rather erect and compact, those on the periphery prostrate, long-creeping and remote. This variation within a mat, together with its associated characters of number and spacing of the leaves, is similar to that found in S. *tortipila* of *Arenicolae*.

Open or lightly shaded bluffs or cliffs and surfaces of igneous rocks, 330–1350 m.

Central California.

Representative specimens:

United States. california: Auburn, Placer Co., April 10, 1865, *Bolander 4511* (B, MO, NY, US); 1892, *A. A. Eaton* (B, NY); Fisher's Cabin, Mokelumne River, Amador and Calaveras counties, April, 1893, *G. Hansen 878* (B, MO, NY, US); *Heller 2583* (F, GH, MO, NY, US), *5466* (GH, MO, NY, US), *8173* (F, GH, MO, NY, US), *10715* (GH, MO, US), *11802* (F, GH, MO, US); 1863, *Hillebrand* (B); *R. M. & A. F. Tryon 5067* (ARIZ, B, BM, CU, DS, F, FI, GH, K, MICH, MIN, MO, NY, P, POM, RM, UC, US, WS).

21. Selaginella **carinata** Tryon, spec. nov. Figs. 25, 26. Map 31.

Caules breves, ramis brevibus propinquis; caules frondosae positione foliorum superorum et inferorum valde dorsiventrales sed forma minus. Folia carnosa, apice carinato vel valde carinato, aspectu laterali truncato vel abrupte declivi, base abrupte adnata cum caule distincta colore, setis abrupte productis colore sensim diversis. Sporophylla marginibus ad basem eciliatis. Megasporae laeves flavae. Typus: *Rose, Pachano & Rose 23039* (US).

Stems short; branches short, approximate; older primary branches once to usually twice, sometimes three times pinnate; leafy stems strongly dorsiventral in position and less so in the shape of the upper and under leaves. Upper leaves

ligulate-long-triangular; apex convexly acute. Under leaves fleshy, none red, lanceolate to ligulate-lanceolate; apex acuminate to convexly acute, carinate to strongly carinate, truncate to abruptly beveled in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform toward the base, dentiform above, the longest cilia ¼ or less as long as the width of the blade; setae arising abruptly in form and evenly in color, ¼ to ½ as long as the blade, rather stout at the base, tapering evenly to the tip, greenish- to lutescent-whitish and subopaque at the base, milk-white and opaque toward the tip. Sporophylls with the margins eciliate toward the base; apex strongly carinate. Megaspores smooth, yellow.

S. *carinata* is a distinctive species and not evidently related to any others. The very short stems and branches and the fleshy leaves with carinate and truncate apex set it off from the other species of this series. Some strobili are slightly dorsiventral, particularly toward the base, apparently a development parallel to that in the African and Madagascar species.

Central Ecuador.

Specimens examined:

Ecuador: Vicinity of Nabón, Sept. 26, 1918, *Rose, Pachano & Rose 23039* (GH, US).

29. S. STEYERMARKII 30. S. HANSENII 31. S. CARINATA

32. S. INDICA 33. S. NJAMNJAMENSIS

22. Selaginella **indica** (Milde) Tryon, comb. nov. Fig. 27. Map 32.

Selaginella rupestris (L.) Spring f. *indica* Milde, Fil. Europ. Atlant. 262. 1867. (Holotype: *Hooker f. & Thomson*).
Selaginella longipila of authors, not Hieron., for example, of Alston, in Proc. Nat. Inst. Sci. India 11:214. 1945.

Stems with the older primary branches once to twice pinnate; leafy stems strongly dorsiventral in position, length and shape of the upper and under leaves. Upper leaves subulate-long-triangular to long-triangular; apex acuminate. Under leaves papyraceous, none red, longer than the upper, long-triangular to ligulate-long-triangular to subulate-lanceolate; apex acuminate, flat, plane in profile. All leaves with the base abruptly adnate, distinct in color, glabrous to slightly pubescent; margins ciliate, the cilia piliform toward the base, dentiform above, the longest cilia ¼ to ½ as long as the width of the blade; setae usually arising evenly in form, less so in color, ¼ as long as the blade, strongly attenuate, tawny to lutescent-whitish, translucent. Sporophylls with the margins eciliate to short-ciliate toward the base; apex rounded to carinate. Megaspores rather finely rugose-reticulate on the commissural face, less prominently marked on the outer face, pale orange.

This species was known as S. *longipila* from the time of the description of that species by Hieronymus, since the specimens were cited as from the Himalayas. However, the labels on Hieronymus' material were erroneous, the specimens being S. *densa* of North America.

S. *indica* is readily distinguished from the other Indian species, S. *Wightii*, by its dorsiventral leafy stem and thin under leaves. The localities taken from the literature (Map 32) are from Alston, in Proc. Nat. Inst. Sci. India 11:214. 1945.

Cliffs, rocky banks and ledges, 700–2800 m.

Nepal, Bhutan, northern and western India.

Specimens examined:

Nepal: *Polunin 1478* (BM).
Bhutan: *Griffith 2871* (BM); *Ludlow et ai. 17039* (BM), *18606* (BM).
India: *Duthie 3727* (BM, US); Khasia, 5000 ft., *J. D. Hooker & T. Thomson* (GH, NY, P, YU).

23. Selaginella njamnjamensis Hieron. in Hedwigia 39:312. 1900. (Holotype: *Schweinfurth* B! fragment NY!). Fig. 28. Map 33.

Stems with the older primary branches once to usually twice pinnate; leafy stems dorsiventral in position, length and slightly in the shape of the upper and under leaves. Upper leaves lanceolate to long-triangular; apex acuminate. Under leaves herbaceous, none red, longer than the upper, linear-lanceolate to lanceolate to long-triangular; apex acuminate, flat to slightly rounded, plane in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous to pubescent; margins ciliate, the cilia usually piliform toward the base, dentiform above, the longest cilia ¼ to nearly ½ as long as the width of the blade; setae arising evenly in form and color, ¼ or less as long as the blade, stout to attenuate,

tawny to lutescent-whitish, subopaque to opaque. Sporophylls on the upper side of the strobilus lanceolate, acuminate, on the under side ovate-long-triangular to narrowly ovate, acuminate, slightly longer and broader; margins short-ciliate toward the base; apex broadly rounded to carinate. Megaspores granular to granular-tuberculate, yellow.

This species is the least dorsiventral of the related species in Africa and Madagascar. Although sufficiently distinct from S. *caffrorum*, both species tend to overlap in the range of variation of the individual characters. The herbaceous under leaves with the base abruptly adnate and distinct in color and the poorly differentiated setae are the primary characters of S. *njamnjamensis*.

On and between exposed rocks, 800–1200 m.

Central and southeastern Africa.

Specimens examined:

ANGLO-EGYPTIAN SUDAN: *Dandy 510* (BM); *Hoyle 520* (BM).
FRENCH EQUATORIAL AFRICA: *Chevalier 6668* (BM,P); *Le Testu 4794* (BM); *Tisserant 3587* (BM).
CENTRAL AFRICA: Njam-Njam, 1870, *Schweinfurth* (B, K, NY, P).
PORTUGESE EAST AFRICA: *Sim 6095* (P).

24. SELAGINELLA CAFFRORUM (Milde) Hieron. in Hedwigia 39:313. 1900.
Fig. 29. Map 34.

Selaginella rupestris (L.) Spring f. *caffrorum* Milde, Fil. Europ. Atlant. 262. 1867. (Holotype: Terra Caffrorum, *Bunge*).
Selaginella rupestris var. *incurva* A. Br. in Kuhn, Fil. Afr. 213. 1868, category taken from annotation of *Welwitsch 169* by A. Br. (Lectotype: *Drège, Lycopodium rupestre a* B. Paratypes: *Ecklon & Zeyher 7* B; *Drège, Lycopodium rupestre aa* B; *Welwitsch 169* B!; *Quartin-Dillon; Steudner*).
Selaginella rupestris var. *incurva* f. *abyssinica* A. Br. in Kuhn, Fil. Afr. 213. 1868, nomen nudum. A single description was provided for "forma capensis et abyssinica". I have seen *Quartin-Dillon*, P, but not *Steudner*, the other specimen cited.
Selaginella rupestris var. *incurva* f. *angolensis* A. Br. in Kuhn, Fil. Afr. 213. 1868. (Holotype: *Welwitsch 169* B!).
Selaginella rupestris var. *incurva* f. *capensis* A. Br. in Kuhn, Fil. Afr. 213. 1868, nomen nudum (see f. *abyssinica*).
Selaginella capensis Hieron. in Hedwigia 39:314. 1900, epithet from S. *rupestris* f. *capensis* A. Br. (Lectotype: *Drège, Lycopodium rupestre a* B. Paratypes: *Ecklon & Zeyher 7* B; *Drège, Lycopodium rupestre aa* B; *R. Baur 1110* B; *Sonder* B!; *Goldschmid* B; *Rehmann 3924* B, *4005* B; *Sutherland* B).
Selaginella Quartiniana Cufodontis, in Phyton 4:178. 1952, nomen nudum, based on S. *rupestris* var. *incurva* f. *abyssinica* A. Br., nomen nudum.

Stems with the older primary branches once to usually twice to rarely three times pinnate; leafy stems dorsiventral in position, length and shape of the upper and under leaves. Upper leaves linear-long-triangular to ligulate-long-triangular; apex acuminate to convexly acute. Under leaves papyraceous to papyraceous-herbaceous, none red, longer than the upper, lanceolate to ligulate-lanceolate to triangular; apex acuminate to convexly acute, flat to slightly rounded, plane or nearly so in profile. All leaves with the base abruptly adnate, distinct from the

stem in color, or the under leaves with the base slightly decurrent and blending in color, glabrous or rarely pubescent; margins ciliate, the cilia piliform, or sometimes dentiform toward the apex, the longest cilia ¼ to ½ as long as the width of the blade; setae arising rather abruptly in form and color, ¼ to ½ as long as the blade, rather stout, whitish to whitish-tawny or whitish-lutescent, translucent to subopaque. Sporophylls on the upper side of the strobilus ovate-lanceolate to long-triangular, on the under side lanceolate-ovate to broadly ovate, acuminate, longer and broader; margins short- to long-ciliate toward the base; apex rounded to carinate. Megaspores rugose-reticulate to granular-rugose on the commissural face, more finely and less prominently marked on the outer face, lemon-yellow.

The thin under leaves and well-differentiated setae are characteristic of *S. caffrorum* and set it off from the related *S. njamnjamensis*. In addition, *S. caffrorum* usually has some of the under leaves on the main stem with decurrent bases.

Dry or moist rocky places, 600–2000 m.

Anglo-Egyptian Sudan to Angola and Union of South Africa.

Specimens examined:

Anglo-Egyptian Sudan: *Jackson 1116* (BM); *MacLeay 114* (BM).

Tanganyika: *Greenway 2431* (BM).

Angola: *Antunes 543* (P); *Dekindt 543* (K, P); Lopolo, Huilla, 5000 ft., April, 1860, *Welwitsch 169* (B, K, NY, P).

Union of South Africa. natal: *Rudatis 857* (P). orange free state: *Rehmann 3924* (P), *3949* (NY, P). basutoland: *Dieterlen 117* (P). cape of good hope: *T. Cooper 662* (NY); Katberg, 4000–5000 ft., *Lycopodium rupestre a, Drège* (GH, K, P, US); *Ecklon & Zeyher* (B, P); *Sonder* (B).

25. Selaginella echinata Baker, in Jour. Linn. Soc. 22:536. 1887. (Holotype: *Baron 4226* K!). Figs. 30, 31. Map 35.

Stems with the older primary branches once to three times, usually twice, pinnate; leafy stems dorsiventral in position, length, shape and in setae characters of the upper and under leaves. Upper leaves ligulate-long-triangular; apex acute; setae arising abruptly, mostly soon deciduous, usually substellate, divided into two to several filiform branches, whitish, translucent to opaque. Under leaves herbaceous-papyraceous, none red, longer than the upper, ovate-lanceolate; apex acuminate, flat to slightly rounded, plane in profile; setae arising very evenly in form and color, ¼ or less as long as the blade, persistent, stout, lutescent to tawny, opaque to subopaque. All leaves with the base adnate to abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform, the longest cilia ¼ to usually ½ as long as the width of the blade. Sporophylls on the upper side of the strobilus broadly ovate-lanceolate, obtuse, on the under side very broadly ovate-triangular, acuminate, longer and broader; margins long-ciliate toward the base; apex broadly rounded to carinate. Megaspores tuberculate, yellow.

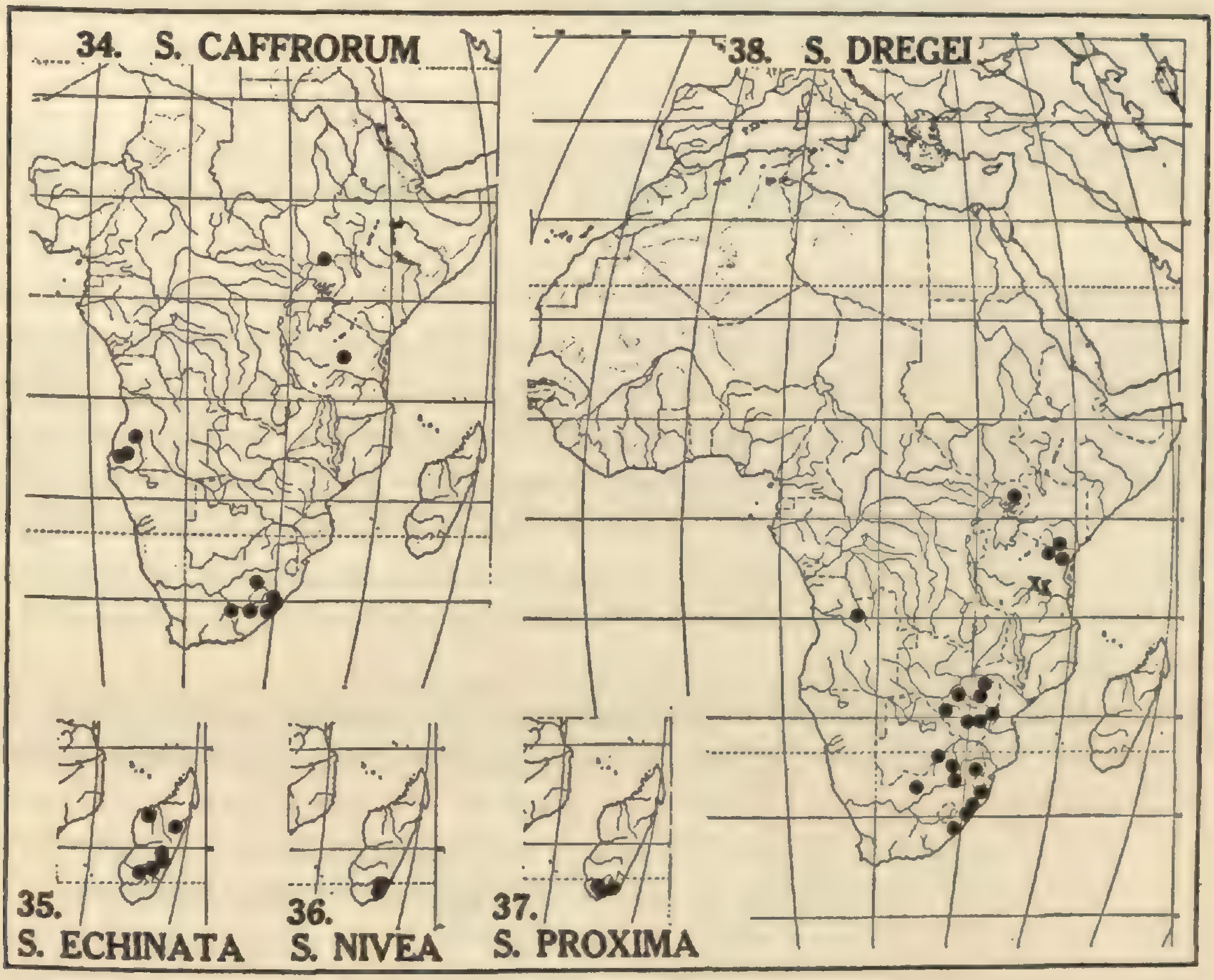
S. echinata is the most distinctive of the three species of Madagascar. It is the most strongly dorsiventral species and in addition has the truly unique character of substellate setae on the upper leaves. Also some leaves and sporophylls have

a unique whitish to tawny, long-appressed pubescence on the back, which among the specimens I have seen is most pronounced in *Perrier 8262*.

Madagascar, 500–2000 m.

Specimens examined:

MADAGASCAR: *Baron 4226* (BM, K); 1879, *Cowan* (BM); *Humbert 2823* (P), *3000* (P), *3538* (P), *11778* (P); *Humbert & Swingle 4791* (P); *Perrier 1168* (P), *8261* (P), *8262* (BM, P), *8311* (BM, P), *8312* (P), *8313* (BM, P), *8324* (P), *8346* (BM, P).



26. SELAGINELLA NIVEA Alston, in Perrier, Cat. Pl. Madagascar, 71. Feb. 1932, nomen nudum; in Dansk Bot. Ark. 7 (C. Chr., Pterid. Madagascar):194. June, 1932. (Holotype: *Perrier 8303* BM!. Paratype. *Perrier 8305* BM!).

Fig. 32. Map 36.

Stems with the older primary branches once to twice pinnate; leafy stems dorsiventral in position and shape of the upper and under leaves. Upper leaves linear-lanceolate to lanceolate; apex acute to acuminate. Under leaves papyraceous, none red, triangular to ligulate-triangular; apex acute to acuminate, flat to slightly rounded, plane in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform toward the base, dentiform above, the longest cilia ¼ or less as long as the width of the blade; setae arising evenly in form, abruptly in color, ¼ to ⅓ as long as the blade, stout, milk-white, opaque. Sporophylls on the upper side of the strobilus lanceolate-ovate, on the under side broadly ovate, acuminate, longer and broader; margins long-

ciliate toward the base; apex broadly rounded to carinate. Megaspores finely granular to nearly smooth, light yellow-orange.

This species has a remarkable superficial resemblance to S. *cinerascens* although in technical characters there is no relationship between them. S. *nivea* may be separated from the next species, S. *proxima*, by the straight and relatively short setae in addition to the characters of habit. S. *nivea* is closely prostrate with the branches once or twice divided. S. *proxima* has the primary branches tending to be ascendent and dendroid and commonly three, rarely four, times divided.

Madagascar, among bushes.

Specimens examined:

Madagascar: *Humbert 11612* (P); *Humbert & Swingle 5518* (BM, GH, P, US); vicinity of Ampanihy, June, 1910, *Perrier 8303* (BM, P), *Perrier 8305* (BM, P), *18702* (P).

27. Selaginella **proxima** Tryon, spec. nov. Figs. 33–35. Map. 37.

Caules ramis primariis saepe dendroideis; caules frondosae positione longitudine et forma foliorum superorum et inferorum dorsiventrales. Folia base abrupte adnata caule distincta colore, marginibus ciliis longissimis longitudine ¼–½ laminae latitudinis, setis ⅓–½ laminae longitudinis valde curvatis juventate praesertim cretaceis caecis. Strobili dorsiventrales sporophyllis stichorum duorum dorsalium deltoideis duorum ventralium ovato-deltoideis longioribus et latioribus. Megasporae leviter rugoso-reticulatae vel laeves citreo-flavae. Typus: *Humbert & Swingle 5705* (US).

Stems with the primary branches tending to be ascendent and dendroid, the older primary branches twice to usually three to rarely four times pinnate; leafy stem dorsiventral in position, length and shape of the upper and under leaves. Upper leaves lanceolate to ligulate-lanceolate; apex acute to obtuse. Under leaves herbaceous, none red, longer than the upper, triangular to ligulate-lanceolate; apex acute to obtuse, flat, plane in profile. All leaves with the base abruptly adnate, distinct from the stem in color, glabrous to pubescent; margins ciliate, cilia piliform, the longest cilia ¼ to ½ as long as the width of the blade; setae arising evenly to abruptly in form, abruptly in color, ⅓ to ½ as long as the blade, stout at the base, usually with a filiform tip, strongly curved, especially those of the branch-tips, milk-white, opaque. Sporophylls on the upper side of the strobilus deltoid to long-deltoid, on the under side ovate-deltoid, longer and broader; margins short- to long-ciliate toward the base; apex broadly rounded to carinate. Megaspores very slightly rugose-reticulate to smooth, lemon-yellow.

The strongly curved setae suggest a relationship to S. *Dregei* while in other characters S. *proxima* is more closely related to the preceding species, S. *nivea*. The differences are discussed under that species.

A bush xerophile, 20–1200 m.

Madagascar.

Specimens examined:

MADAGASCAR: *Humbert 6557* (P), *7089 bis* (P), *12439* (P), *12706* (P), *13338* (P), *14158* (P); *Humbert & Swingle 5581* (P), vicinity of Fort Dauphin, near Bevilany, 200–300 m., Sept. 14, 1928, *Humbert & Swingle 5705* (GH, P, US).

28. SELAGINELLA DREGEI (Presl) Hieron. in Hedwigia 39:315. 1900.

Fig. 36. Map 38.

Lycopodium Dregei Presl, in Abhandl. Böhm. Gesell. Wissen. V, 3 (Bot. Bermerkungen): 583, reprint 153. 1844. (Holotype: *Drège, Lycopodium rupestre b* PRC. *Drège, Lycopodium rupestre a* is excluded as a type; it is *S. caffrorum*).

Selaginella rupestris (L.) Spring f. *Dregei* (Presl) Milde, Fil. Europ. Atlant. 262. 1867.

Selaginella rupestris var. *recurva* A. Br. in Kuhn, Fil. Afr. 213. 1868, category taken from annotation of *Welwitsch 48* and *Drège, Lycopodium rupestre b* by A. Br. (Lectotype: *Drège, Lycopodium rupestre b* B!. Paratypes: *Welwitsch 48* B!, *49* B).

Selaginella rupestris var. *recurva* f. *Dregeana* A. Br. in Kuhn, Fil. Afr. 214. 1868, based on *Lycopodium Dregei* Presl as to *Drège, Lycopodium rupestre b.*

Selaginella rupestris var. *recurva* f. *Welwitschiana* A. Br. in Kuhn, Fil. Afr. 214. 1868: (Lectotype: *Welwitsch 48* B!. Paratype: *Welwitsch 49* B).

Selaginella Dregei var. *pretoriensis* Hieron. in Hedwigia 39:317. 1900. (Lectotype: *Rehmann 4333* B!. Paratype: *Wilms 1814* B).

Selaginella Dregei var. *Rehmanniana* Hieron. in Hedwigia 39:317. 1900. (Lectotype: *Rehmann 5576* B!. Paratype: *Braga 98* B).

Selaginella Dregei var. *Bachmanniana* Hieron. in Hedwigia 39:317. 1900. (Holotype: *Bachmann 9* B!).

Selaginella Dregei var. *Petersiana* Hieron. in Hedwigia 39:317. 1900. (Holotype: *Peters* B!).

Selaginella Dregei var. *Hildebrandtiana* Hieron. in Hedwigia 39:317. 1900. (Lectotype: *Hildebrandt 2363* B!. Paratypes: *Fischer 627* B, fragment NY!; *Stuhlmann 910* B, *4305* B).

Selaginella Dregei var. *Welwitschiana* (A. Br.) Hieron. in Hedwigia 39:318. 1900.

Selaginella grisea Alston, in Jour. Bot. 77:222. 1939, based on *S. Dregei* var. *Hildebrandtiana* Hieron.

Stems often irregularly ascendent, buds rarely present at the base of the branches, older primary branches once to twice, rarely three times, pinnate; leafy stems radially symmetrical to somewhat dorsiventral in position and sometimes also in shape of the upper and under leaves. Leaves herbaceous to herbaceous-papyraceous, none red, subulate to long-triangular to ligulate-long-triangular; base abruptly adnate, distinct from the stem in color, glabrous; margins ciliate, the cilia piliform, the longest cilia ½ as long to as long as the width of the blade; apex acuminate to long-acuminate, flat to slightly rounded, plane in profile; setae arising evenly in form and usually in color, ⅓ to usually ½ as long to as long as the blade, attenuate, usually strongly curved, especially those of the growing-points, milk-white and opaque to rarely tawny-whitish, subopaque. Sporophylls in 2 ranks on the under side of the branch-tip; margins eciliate to long-ciliate toward the base; apex broadly rounded. Megaspores slightly tuberculate on the commissural face, similar to slightly rugose on the outer face, with an equatorial ridge, yellow to orange.

The unilateral strobilus of this species is one of the most unique characters of any in the section. There are two rows of sporophylls on the under side of the

branch tip while vegetative leaves replace the usual two rows on the upper side. This character is sufficient to identify the species in spite of considerable variation in other characters such as the color, length and degree of curving of the setae, the leaf shape, the symmetry of the leafy stem, the number and length of the cilia on the leaves and the shape of the sporophylls. Except that the dorsiventral specimens have the broader under leaves, none of the variations correlate with each other or with a coherent distribution.

Some sterile material with straight setae such as *Peters*, Mozambique, is difficult to place. However, such specimens as *Moss 18988* BM which is otherwise similar, are fertile and can be placed with certainty.

S. *Dregei* is variable in habit, the stems varying from closely prostrate to loosely and irregularly ascending. In the latter case the rhizophores may be unusually long. Rarely, some stems will have short branches at the base which will actively grow upon the death of the portions above. This character is otherwise found only in *Arenicolae* where it is well developed and constant in such species as S. *rupincola* and S. *arenicola.*

The localities taken from the literature (Map 38) are from Alston, in Jour. Bot. 77:222. 1939.

Exposed or sheltered rocky places, on or among igneous or sandstone rocks, 700–2300 m.

Southern and eastern Africa.

Representative specimens:

Uganda: *Eggeling 2619* (US).

Kenya: *Fischer 627* (B, NY); Egu, between Duruma and Taita, Jan. 1877, *Hildebrandt 2363* (B, BM, K, NY, P).

Portugese East Africa (Mozambique): *Gomes & Sousa 85* (BM); *Peters* (B).

Rhodesia: *Munro 1777* (BM, P, US), *1883* (BM); *Rodin 4403* (MO, US).

Angola: *Exell & Mendonca 169* (BM); Pedras de Guinga, Pungo Andongo, 3800 ft., March, 1837, *Welwitsch 48* (B, K, P).

Bechuanaland: *Burchell 2315* (GH).

Union of South Africa. transvaal: *Leendertz 935* (BM, P), *2568* (F); Aapies-river, Pretoria, *Rehmann 4333* (B, K), Houtbosh, *Rehmann 5576* (B, K); *Wilms 1814* (NY, P). natal: Omsamcaba, 1844, *Lycopodium rupestre b, Drège* (B, K, P); *W. T. Gerrard* (P); *J. M. Wood 11950* (F). orange free state: *Rehmann 3949* (P). cape of good hope: Pondoland, 1887–88, *Bachmann 9* (B, P).

Series **Rupestres** Tryon, ser. nov.

Rhizomata et stolones nulla, gemmae breves simplices ad bases caulium rare praesentes vel absentes. Caules prostrati, ramis rare pendulis. Apices ramorum recti vel leviter curvati statu inerte. Caules frondosi leviter dorsiventrales vel radialiter symmetricales. Folia base decurrente vel valde decurrente. Typus: *Selaginella rupestris* (L.) Spring.

Plants terrestrial or, in S. *oregana,* usually epiphytic; rhizomes and stolons absent, short, simple basal buds absent or, in S. *oregana,* occasionally present. Stems prostrate with rhizophores produced generally throughout or, in S. *oregana,*

the branches usually pendent with rhizophores only on the prostrate main stems. Branches straight or slightly curled in the dormant state or, in S. *oregana,* strongly curled; branch tips straight or slightly curved in the dormant state. Leafy stems radially symmetrical, the leaves equal in position, length and shape on all sides on the same portion of the stem, or dorsiventral in position, the under leaves loosely appressed, the upper erect-ascending, and sometimes also in length, the under slightly longer than the upper; zone of green leaves equal or nearly equal on all sides of the stem. Leaf-bases strongly decurrent on all sides of the stem or those on the upper side decurrent. Setae of the sporophylls terete or oval at the base or often, in S. *densa* and S. *sibirica,* with the base strongly broadened and flattened. Megaspores 4 in a megasporangium; rarely 1–2, or in S. *rupestris* commonly 1–2.

The *Rupestres* is a rather homogeneous series. Although the species are sufficiently distinctive they do not differ from each other by as many characters as the members of the other series. The last three species, S. *utahensis,* S. *leucobryoides* and S. *asprella,* share the peculiar character of easily fragmenting stems and this is also present, although to a lesser degree, in S. *Watsonii.* These four species form the only definite group within the series. S. *Vardei,* with some of the leaves rarely with abruptly adnate bases, may illustrate a transition from *Arenicolae.* The dorsiventral S. *densa* appears to be an example of parallel evolution and not related by that character to *Eremophilae* or the dorsiventral *Sartorii.* S. *rupestris* is notable for its development of apogamy and S. *densa* and S. *sibirica* rarely show a tendency toward such a development.

KEY TO SPECIES

a. Dry leafy stems persistently whole, not fragmenting; stems forming cushion mats with discrete branches, *or* spreading mats with intricate branches, *or* pendent, forming festoons, *or* if forming cushion mats with intricate branches then the apex of the upper leaves fleshy. b.

b. Stems forming flat mats with discrete branches *or* spreading mats with intricate branches, *or* pendent, forming festoons; apex of the upper leaves herbaceous to slightly fleshy, plane to abruptly beveled in profile; *or* if the apex of the upper leaves fleshy and truncate in profile then the setae of the leaves ⅓ to over ½ as long as the blade and the broadest sporophylls about 4 times as broad as the leaves. c.

c. Stems elongate, branches long and remote, intricate; apex of the upper leaves plane in profile; broadest sporophylls about 4 times as broad as the leaves. China .... 29. S. *Vardei,* p. 61

c. Stems short, the branches short, approximate, discrete; *or* the apex of the upper leaves beveled to truncate in profile; *or* the broadest sporophylls about 2 times as broad as the leaves. d.

d. Plants usually epiphytic, the stems pendent with rhizophores only at or near the base; leaves adnate to the stem for ¼ to usually ⅓ to nearly ½ their length; branches strongly curled in the dormant state. Coastal Washington to northern California ... 30. S. *oregana,* p. 61

d. Plants terrestrial, usually with rhizophores throughout; upper leaves adnate to the stem for 1/5 to rarely 1/4 their length; branches not or slightly curled in the dormant state. e.

e. Apex of upper leaves nearly plane to abruptly beveled in profile, *or* if truncate then the setae lutescent and the stems forming compact flat mats with discrete branches. f.

f. Upper and under leaves essentially or quite equal in length on the same portion of the stem; stems forming open, spreading mats with intricate branches; base of setae of the sporophylls not or slightly broadened and flattened. g.

g. Broadest sporophylls about 2 times as broad as the leaves; sporophylls and leaves eciliate or with cilia strongly ascending and dentiform toward the apex. Texas to Arizona, north to Wyoming .... 31. S. *Underwoodii*, p. 62

g. Broadest sporophylls about 4 times as broad as the leaves; sporophylls and leaves with cilia spreading to laxly ascending and piliform toward the apex. Georgia to Greenland, west to Arkansas, Nebraska and Alberta .... 32. S. *rupestris*, p. 64

f. Upper and under leaves unequal in length on the same portion of the stem, the under definitely longer; stems forming compact mats with discrete branches; base of setae of the sporophylls often strongly broadened and flattened. Texas to Arizona; California; north to Saskatchewan, Alaska and British Columbia .... 33. S. *densa*, p. 66

e. Apex of the upper leaves truncate in profile; setae white to tawny; stems forming open, spreading mats with intricate branches. Yukon to Siberia and Japan .... 34. S. *sibirica*, p. 71

b. Stems forming rounded cushion mats with intricate branches; apex of the upper leaves fleshy, truncate or subtruncate in profile; setae of the leaves 1/5 to 1/4, rarely 1/3, as long as the blade; broadest sporophylls about 2 times as broad as the leaves. California to Oregon and Montana .... 35. S. *Watsonii*, p. 72

a. Dry leafy stems readily fragmenting; stems forming cushion mats with usually intricate branches; apex of the upper leaves herbaceous to slightly fleshy. Southwestern Utah to southern California. h.

h. Setae not forming a conspicuous tuft at the growing-tip, 1/5 or less as long as the blade. i.

i. Setae essentially absent or, if present, then smooth, whitish to greenish- or lutescent-whitish, subopaque. Southwestern Utah and southeastern Nevada .... 36. S. *utahensis*, p. 74

i. Setae scabrous, white, usually opaque. Southeastern California .... 37. S. *leucobryoides*, p. 74

h. Setae forming a conspicuous tuft at the growing-tip, ⅓ to more than ½ as long as the blade, scabrous, white, usually translucent. Southern California ....38. *S. asprella*, p. 75

29. SELAGINELLA VARDEI Lév. Cat. Pl. Yun-Nan, 172. 1917. (Holotype: *Maire 56* E). Fig. 37. Map 39.

Stems long, forming open, spreading mats; branches long, remote, intricate, not fragmenting when dry. Upper and under leaves about equal in length on the same portion of the stem; leaves subulate to subulate-long-triangular; base pubescent, that of the upper leaves adnate to the stem for ¼ or less their length; margins ciliate, the cilia strongly ascending toward the apex of the blade; apex of the upper leaves herbaceous, flat to slightly rounded, plane or nearly so in profile; setae forming conspicuous tufts at the dry branch-tips, ⅓ to ½ as long as the blade, usually slightly scabrous, tawny to whitish-tawny, translucent. Sporophylls with the cilia dentiform and ascending toward the apex, the broadest about 4 times as broad as the leaves. Megaspores unknown.

On the basis of its generalized characters, this species is placed as the most primitive in the series. One specimen examined had several of the leaves abruptly adnate and distinct in color at the base, characters of the previous series, *Sartorii.*

In the material examined only microsporangia were found and these occurred in the basal sporophylls as well as those above. The explanation of this in terms of the reproduction of the species is not clear. It suggests that the stems may be monoecious or dioecious but fertilization would be extremely unlikely under such circumstances. The localities taken from the literature (map 39) are from Alston, in Bull. Fan Mem. Inst. 5:267. 1934.

Exposed rocky places, 1500–3800 m.

Szechwan, Yunnan and Tibet.

Specimens examined:

CHINA. SZECHWAN: *H. Smith 2394* (BM); *E. H. Wilson 5411* (P). YUNNAN: *J. W. & C. J. Gregory* (BM); Siao-ou-long, 2900 m., Oct. 1912, *Maire 56* (BM). TIBET: *Ludlow et al. 4116* (BM), *5494* (BM), *14233* (BM).

30. SELAGINELLA OREGANA D. C. Eaton, in Wats. Bot. Calif. 2:350. 1880. (Lectotype by Weath. in Jour. Arn. Arb. 25:411. 1944: *Kautz* YU!. Paratype: *Summers 2209* YU!). Fig. 38. Map 40.

Plants epiphytic with rhizophores only at the base of the stems, less often terrestrial with rhizophores borne throughout. Stems very long to long, forming pendent festoons; branches long, remote, intricate or discrete, strongly curled in the dormant state, not fragmenting when dry; or terrestrial stems forming an irregular mat with intricate branches. Upper and under leaves essentially or quite equal in length on the same portion of the stem; leaves long-triangular to ovate-triangular, excluding the adnate base; base glabrous, rarely pubescent, that of the upper leaves adnate to the stem for ¼ to nearly ½ their length; margins eciliate to ascending-ciliate toward the apex; apex of the upper leaves slightly fleshy,

rounded to narrowly carinate, plane to gently beveled in profile; setae not or hardly forming conspicuous tufts at the dry branch-tips, about ⅕ as long as the blade, smooth, greenish, whitish or lutescent, translucent to rarely subopaque. Sporophylls eciliate toward the apex, the broadest about 2 times as broad as the leaves. Megaspores rugose-reticulate with thin rugae on the commissural face, less marked on the outer face, pale yellow.

S. *oregana* is the only species of the section that is commonly an epiphyte and its long pendent branches are characteristic. Perhaps in relation to the length of the branches, the leaf-base is unusually long and the desiccated branches curl to form ringlets. The last two characters are sufficient for the identification of the occasional plants that grow on soil or rock.

The specimen collected by Scouler (*335*, GH, NY) and frequently cited can not be accepted as coming from Observatory Inlet as stated on the label since this locality is so far north of the otherwise known range.

In megaspore characters S. *oregana* shows a relationship to S. *Underwoodii*, which occasionally has pendent branches although it is not an epiphyte.

Pendent from mossy trunks or branches of trees, particularly *Acer macrophyllum*, or on shaded rocky banks, sea level to 200 m.

Coastal Washington to northern California.

Representative specimens:

United States. washington: *A. A. & E. G. Heller 4002* (MO, NY, US); *Otis 1399* (GH, NY, US); *Piper 3802* (GH, MO, NY, US); *Suksdorf 6736* (GH, MO, US), *6811* (GH, MO, US); *Thompson 5932* (GH, MO, NY, US), *6241* (GH, MO), *9399* (GH, NY, US), *11425* (GH, MO, NY). oregon: *E. Hall 694* (F, GH, MO, NY, US); July 12, 1882, *T. Howell* (F, GH, MO, NY, US); Fort [Port] Orford, 1855, *Lieut. A. V. Kautz* (GH, K, US, YU); Oct. 29, 1881, *Pringle* (F, GH, MO, NY, US); *Summers 2209* (YU); *Thompson 4115* (MO, NY, US), *12752* (MO, NY, US). california: *Eastwood 12185* (F, GH); *T. Howell 696* (GH, US); *H. E. Parks 24274* (F, GH, MO, NY); *H. E. & S. T. Parks 24119* (F, GH, NY, US).

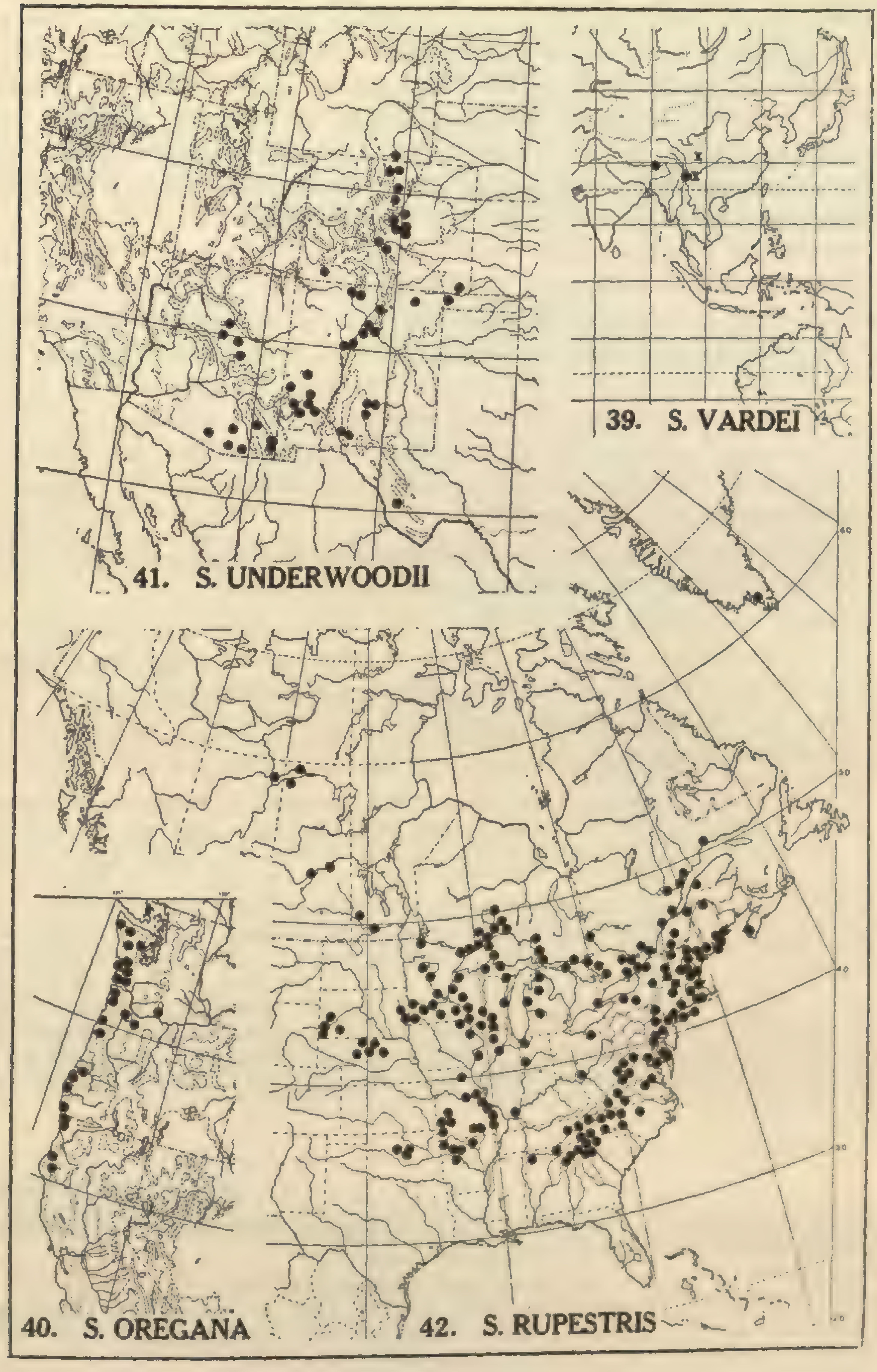
31. Selaginella Underwoodii Hieron. in Engl. & Prantl, Nat. Pflanz. 1⁴:714. 1901, based on S. *rupestris* var. *Fendleri* Underw. Figs. 39, 40. Map 41.

Selaginella rupestris (L.) Spring var. *Fendleri* Underw. in Bull. Torr. Bot. Club 25:127. 1898. (Lectotype by Weath. in Jour. Arn. Arb. 25:412. 1944: *Fendler 1024* NY!. Paratypes: *Baker 2* NY!; *Wooton* in 1892 NY!).

Selaginella Fendleri (Underw.) Hieron. in Hedwigia 39:303. 1900, not Baker, 1887.

Selaginella Underwoodii var. *dolichotricha* Weath. in Jour. Arn. Arb. 25:412. 1944. (Holotype: *Metcalfe 276* GH! fragment US!. Paratypes: *Ferriss* in 1904 GH!; *Gooding 5* US! fragment GH!; *Maguire et al. 11745* GH!; *Metcalfe 711* US! fragment GH!, *991* GH!).

Stems long or moderately long, forming open, spreading mats, rarely pendent and forming festoons; branches long and remote or moderately so, intricate, not fragmenting when dry. Upper and under leaves equal or subequal in length on the same portion of the stem; leaves subulate to linear to ligulate-long-triangular; base glabrous to pubescent, that of the upper leaves adnate to the stem for about ⅕ their length; margins ciliate, the cilia ascending toward the apex; apex of the



39. S. VARDEI

41. S. UNDERWOODII

40. S. OREGANA

42. S. RUPESTRIS

upper leaves herbaceous to slightly fleshy, slightly rounded to narrowly carinate, plane to abruptly beveled in profile; setae sometimes forming conspicuous tufts at the dry branch-tips, 1/5 as long to nearly as long as the blade, usually smooth, sometimes scabrous, whitish, greenish-white to lutescent, rarely milk-white, usually translucent to rarely opaque. Sporophylls eciliate or with cilia dentiform and ascending toward the apex, the broadest usually 2 to rarely 3 times as broad as the leaves. Megaspores rugose-reticulate on the commissural face, more prominently marked, often with thin rugae, on the outer face, pale orange.

On the basis of the material I have studied I am not able to recognize var. *dolichotricha*. It is a considerably less well-defined entity than others I have recognized as varieties. S. *Underwoodii* from northern Arizona, northern New Mexico and northward is rather uniform in having short and well-differentiated setae and mostly short cilia on the leaves. However, to the south this extreme is also found with the phase that has long and poorly differentiated setae and long cilia. The three characters do not correlate as well as one would like in this area. This is a close parallel to S. *mutica* but in that species the differentiation has proceeded further and varieties are recognized.

S. *Underwoodii* often grows with S. *mutica* and as mentioned under that species the S. *Underwoodii* in such mixed mats eventually disappears.

Moist or shaded cliffs or rocky slopes, rocky alpine meadows, in crevices or on ledges or among rocks, usually on granitic or other igneous rocks, less often on sandstone or limestone, 800–4000 m., usually from 2000–3000 m.

Texas to Arizona, north to Wyoming.

Representative specimens:

United States. wyoming: *Payson 2503* (US). colorado: *C. F. Baker 2* (NY, US); *C. S. Crandall 1054* (NY, US); *Johnston 2424* (GH, US), *2425* (GH, NY, US); *R. M. & A. F. Tryon 5074* (ARIZ, B, BM, CU, F, FI, GH, K, MO, NY, P, PH, RM, UC, US, WS), *5076* (BM, DS, GH, MIN, MO, POM, US), *5078* (B, BM, F, GH, MICH, MO, NY, P, US). new mexico: *Arsène 15872* (F, MO), *17963* (F, US); 1874, *Fendler 1024* (B, F, GH, MO, NY, US); Mogollon Mountains, Mogollon Creek, Socorro Co., 8000 ft., July 20, 1903, *Metcalfe 276* (GH, MO, NY, US); *Metcalfe 711* (GH, MO, NY, US), *991* (F, GH, MO, NY, US); *Richards & Drouet 363* (F, GH, MO, NY); March 1, 1892, *Wooton* (NY). oklahoma: Aug. 14, 1937, *Wherry* (US). texas: *Ferris & Duncan 3588* (NY, US); *Hinckley 1011* (GH, US), *1156* (US). arizona: *Darrow & Phillips 2781* (GH, MO, US); March, 1904, *Ferriss* (GH); *Goodding 5* (GH, US), *213* (GH, NY); *Maguire et al. 11745* (GH, US); *Phillips 2866* (GH, MO, US); *Pultz & Phillips 2749* (GH,US).

32. Selaginella rupestris (L.) Spring, in Mart. Fl. Bras. 1^2:118. 1840.

Figs. 41, 42. Map 42.

Lycopodium rupestre L. Sp. Pl. 2:1101. 1753. (Lectotype: *Kalm* LINN!. Kamtchatcha, *Steller* LINN! is excluded as a type; it is S. *sibirica*).

Stachygynandrum rupestre (L.) Beauv. Prod. Aethiog. 110. 1805.

Selaginella Bourgeaui Hieron. in Hedwigia 39:295. 1900, as *Bourgeauii*. (Lectotype: *Bourgeau* on Aug. 15, 1857 B!; Black Hills, *Hayden* MO! is an excellent match. Paratype: *Bourgeau* on Aug. 14, 1857, in part, B! fragment NY!).

Selaginella rupestris f. *Bourgeaui* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Stems long to rather short, forming open, spreading mats; branches long and remote to moderately short and subapproximate, intricate, rarely only slightly so, not fragmenting when dry. Upper and under leaves equal or subequal, rarely the under slightly longer, on the same portion of the stem; leaves subulate to ligulate-long-triangular; base usually pubescent, rarely glabrous, that of the upper leaves adnate to the stem for 1/5 to 1/4 their length; margins ciliate, the cilia spreading toward the apex; apex of the upper leaves herbaceous, rounded, gently to abruptly beveled in profile; setae forming conspicuous tufts at the dry branch-tips, nearly 1/2 to 3/4 as long as the blade, scabrous, usually strongly so, milk-white to tawny, opaque to rarely subopaque. Sporophylls with the cilia piliform and spreading toward the apex, rarely laxly ascending, the broadest about 4 times as broad as the leaves. Megaspores usually 1–2, less often 3 or 4 in a sporangium, rugose to rugose-reticulate, more finely marked on the outer face, bright orange.

S. *rupestris* is the only species that is certainly apogamous. In the Appalachian mountain region as far north as southern Pennsylvania most of the material has four megaspores in a sporangium and microsporangia are present in the strobilus. Such plants are presumably sexual. In some plants the spore number in the sporangia of a strobilus may vary from 1 to 4. Those having 1–2 megaspores in the sporangia and a few microsporangia are less common. Throughout the rest of the range the most frequent type bears only megasporangia with either 1 or 2 megaspores. This must be an obligate apomict and it is the only kind in a broad band on the northern periphery of the range. From Missouri to Michigan and Vermont there rarely occur specimens that bear strobili having a few microsporangia. The widespread apogamy may explain the uniformity of S. *rupestris* over its broad range. All other wide-ranging species are much more variable. The occasional occurrence of 1–2 megaspores in sporangia of S. *densa* and S. *sibirica* may also indicate apogamy.

S. *rupestris* most closely resembles S. *densa* var. *densa* and it can best be separated by its radially symmetrical leafy stem. In addition, in the area in Canada where the two grow together, all of the S. *rupestris* have one or two megaspores in a sporangium while S. *densa* has, with rare exception, four. When S. *rupestris* grows in nearly pure sand and other vegetation is sparse it will form circular, or in age, ring-shaped mats.

Exposed or less often shaded cliffs, rocky bluffs, of acidic igneous or sedimentary rocks, gravel or sandy soil, up to 1900 m.

Central and eastern United States to northeastern Alberta, Quebec and Greenland.

Representative specimens:

GREENLAND: July 13, 1946, *T. W. Böcher* (GH).

CANADA. NOVA SCOTIA: *Fernald & Long 23098* (GH, US). QUEBEC: *Victorin 8421* (MO, US); *Victorin et al. 4201* (MO, US). ONTARIO: *C. E. & G. K. Jennings 7362* (GH, US), *7389* (GH, US); July 20, 1899, *Umbach* (MIN, NY, US); *Van Eseltine 501* (GH, US). MANITOBA: Fort Ellice, Aug. 15, 1857, *Bourgeau* (B), Aug. 14, 1857 (B, NY); *Macoun 137* (BM); *Macoun & Herriot 70372* (B, F, GH, NY). SASKATCHEWAN:

Raup 6305 (GH, NY), *6929* (GH, NY). ALBERTA: *Raup & Abbe 4451* (GH, NY), *4608* (GH, NY).

United States. MAINE: *Hodgdon* (Pl. Exsicc. Gray. 611) (F, GH, MO, NY, US). VERMONT: Sept. 11, 1920, *Dutton* (F, GH, MO); *Eggleston 2199* (GH, NY, US). CONNECTICUT: 1859, *D. C. Eaton* (F, GH, MO). NEW YORK: *Robinson & Maxon 15* (GH, NY, US), *32* (F, GH, MO, NY, US). PENNSYLVANIA: *Heller & Halbach 706* (GH, MO, US). VIRGINIA: *Steele & Steele 166* (GH, MO, NY, US). NORTH CAROLINA: *Biltmore Herb. 3432a* (NY, US). SOUTH CAROLINA: *Mackenzie 2997* (MO, US); *Clausen & Trapido 3663* (NY, US). GEORGIA: *Beyrich 198* (US); *Correll 6615* (GH, MO, US); *Harper 215* (GH, MO, NY). ALABAMA: *Harper 3403* (F, MO). MICHIGAN: *R. W. Chaney 181* (F, GH, US); *R. M. & P. F. Tryon 4695* (GH, MO). INDIANA: June 16, 1900, *Umbach* (GH, US). TENNESSEE: *Gattinger* (Curtiss, N. Am. Pl. 3796) (F, GH, MO, NY, US). WISCONSIN: *R. M. & A. F. Tryon 5005* (B, BM, GH, K, MO, P, US). ILLINOIS: *A. Chase 1584* (F, US); *Evers 32650* (MO). MINNESOTA: *Bergman 3156* (GH, NY, US); *Moyle 483* (F, GH, MO, US). MISSOURI: *Bush 4744* (GH, MO, NY, US), *5210* (GH, NY, US). ARKANSAS: *E. J. Palmer 35561* (F, GH, MO, NY). SOUTH DAKOTA: *Murdoch 4304* (F, GH, US). NEBRASKA: *Kiener 11323* (US), *23695* (MO). KANSAS: 1886, *E. N. Plank 14* (GH). OKLAHOMA: *Bush 835* (GH, MO, NY).

33. Selaginella densa Rydb. in Mem. N. Y. Bot. Gard. 1:7. Feb. 15, 1900. (Holotype: *Havard* NY! marked as type by Rydb., fragment US!. Paratypes: *Newberry* NY!; *Williams 534; Tweedy 172;* Missoula, Mont. 1898, *Williams & Griffith;* Silver Bow Co., Mont., *Mrs. Jennie Moore;* the last four collections probably at MONT. *Watson* in 1880 GH! is excluded as type material; it is S. *Wallacei*). Map 43.

Stems short, forming flat cushion mats; branches short, approximate, discrete, not fragmenting when dry. Under leaves definitely longer than the upper on the same portion of the stem, or sometimes equal to the upper on the assurgent branch-tips; leaves ligulate to ligulate-lanceolate to ligulate-long-triangular; base glabrous to pubescent, that of the upper leaves adnate to the stem for ⅕ to ¼ their length; margins eciliate or with the cilia ascending to spreading toward the apex; apex of the upper leaves herbaceous to fleshy, slightly to broadly rounded, plane to truncate in profile; setae forming conspicuous tufts at the dry branch-tips, ¼ to ¾ as long as the blade, smooth to scabrous, milk-white and opaque to tawny or whitish and subopaque to lutescent and translucent. Sporophylls eciliate or with the cilia dentiform to piliform and ascending, rarely laxly ascending, toward the apex, the broadest 3 to 4 times as broad as the leaves; seta base often strongly broadened and flattened. Megaspores prominently and coarsely rugose-reticulate to slightly rugose, most prominently marked in the equatorial region, pale to bright orange.

S. *densa* is one of the most complex species of the section. The morphological extremes of the three varieties are amply distinct, but from Montana south to Colorado all occur and with an increasing number of intermediates. In Colorado nearly all possible intermediate conditions between the three may be found and over a third of the collections I have seen from there are such intermediates. To the south, in the mountains of Arizona, New Mexico and Texas, there is less variation. Var. *Standleyi* and var. *densa* are lacking and there are no intermediates with var. *Standleyi*. The material there is either typical var. *scopulorum* or intermediates of it varying toward var. *densa*.

It is not possible to withhold recognition from the three extremes since they do have distinctive characters and distribution in the northern part of the range of the species. At the same time, it must be admitted that identification, particularly of the material from Colorado, is sometimes rather arbitrary. The intermediates show all transitions between the two extremes in respect to the varietal characters. Some specimens will be intermediate in one character, others in two or three. Some will have some of the leaves and sporophylls intermediate, others typical of one variety; or some leaves and sporophylls will be typical of one variety, others of them typical of another variety.

The intermediate specimens have, for the purposes of discussion, been divided into two kinds. Those that are more or less halfway between the typical state of two varieties are called intermediate. Those that depart from the typical state of a variety to a lesser degree are mentioned as specimens showing a tendency toward another variety. Such specimens can be identified with one variety quite satisfactorily but are not entirely typical of it.

Of the three varieties, var. *densa* most closely resembles S. *rupestris* and the differences are discussed under that species. Rarely S. *densa* may have some megasporangia with two megaspores but this has not been found with sufficient regularity within a strobilus to indicate functional apogamy as in S. *rupestris*.

Southwestern Manitoba to southern Alaska, south to Texas, Arizona and northern California.

KEY TO VARIETIES

a. Apices of the leaves and sporophylls plane to abruptly beveled in profile; setae of the leaves white or whitish, or lutescent only at the base, opaque to subopaque. b.

  b. Sporophylls eciliate toward the apex..................33a. var. *scopulorum*, p. 67

  b. Sporophylls dentiform to piliform-ciliate to the apex...33b. var. *densa*, p. 68

a. Apices of the leaves and sporophylls predominantly or all truncate in profile; setae of the leaves whitish- to greenish- to entirely lutescent, translucent..33c. var. *Standleyi*, p. 71

√ 33a. SELAGINELLA DENSA var. scopulorum (Maxon) Tryon, comb. nov.
Fig. 43. Map 44.

Lycopodium bryoides Nutt. ex Baker, Handb. Fern Allies, 35. 1887, in synon. Placed here on the basis of the specimen so labeled at Kew! (fragment NY!) which agrees with Baker's description.

Selaginella scopulorum Maxon, in Amer. Fern Jour. 11:36. 1921. (Holotype: *Standley 15732* US!. Paratypes: *Ferris & Duthie 941* US!; *Flett 3092* US!; *Goodding 483* US!; *Heacock 235* US!; *Mearns 4274* US!; *Merrill & Wilcox 1218* US!; *Shaw 398* US!, *902* US!, *1060* US!; *Standley 15318a* US!, *15598* US!, *16216* US!, *16255* US!, *16288* US!, *16378* US!, *17055* US!, *17164a* US!, *17979* US!, *18050* US!, *18185* US!; *Suksdorf 8834* US!; *Ulke* on Aug. 25, 1917 US!; *Umbach 856* US!).

Selaginella columbiana A. A. Eaton ex Maxon, in Amer. Fern Jour. 11:37. 1921, in synon. (Evidently based on *Shaw 398* and *Heacock 235*).

Apex of leaves plane to abruptly beveled in profile; setae white, or lutescent only at the base, opaque, rarely subtranslucent. Sporophylls eciliate toward the apex; apex plane to gently beveled in profile.

Var. *scopulorum* is apparently the least specialized of the varieties of S. *densa.* Intermediates with var. *densa* in the central and southern Rocky Mountains are frequent but intermediates with var. *Standleyi* are rare.

The following are examples of intermediates between var. *scopulorum* and var. *densa.* New Mexico, *Arsène & Benedict 16370* (US); Arizona, *Phillips & Reynolds 2900* (GH); Colorado, *Underwood & Selby 133* (NY); Utah, *Hermann 5063* (MO).

Examples of specimens of var. *scopulorum* with a tendency toward var. *densa* are: Colorado, *Knowlton 82* (US), *McKelvey 4695* (GH); Utah, *Harrison & Larsen 7891* (MO); Arizona, *Phillips & Reynolds 2900* (US).

Colorado, *Rydberg & Vreeland 6588* (NY) represents var. *scopulorum* with a tendency toward var. *Standleyi.*

Intermediates between var. *scopulorum* and var. *Standleyi* are mentioned under that variety while specimens of var. *densa* with a tendency toward var. *scopulorum* are mentioned under var. *densa.*

Usually in rocky alpine tundra, also cliffs, talus slopes, on ledges, among boulders or in thin soil over rocks, on igneous or sedimentary rocks, 700–4660 m.

Alberta to British Columbia, south to Texas, Arizona and northern California.

Representative specimens:

Canada. alberta: *Scamman 2790* (GH); *Rosendahl 1074* (US). british columbia: *Heacock 235* (BM, GH, MO, NY, US); *Hitchcock & Martin 7435* (GH, MO, NY); *Shaw 398* (BM, GH, MO, NY, US), *902* (BM, GH, NY, US), *1060* (BM, GH, MO, NY, US).

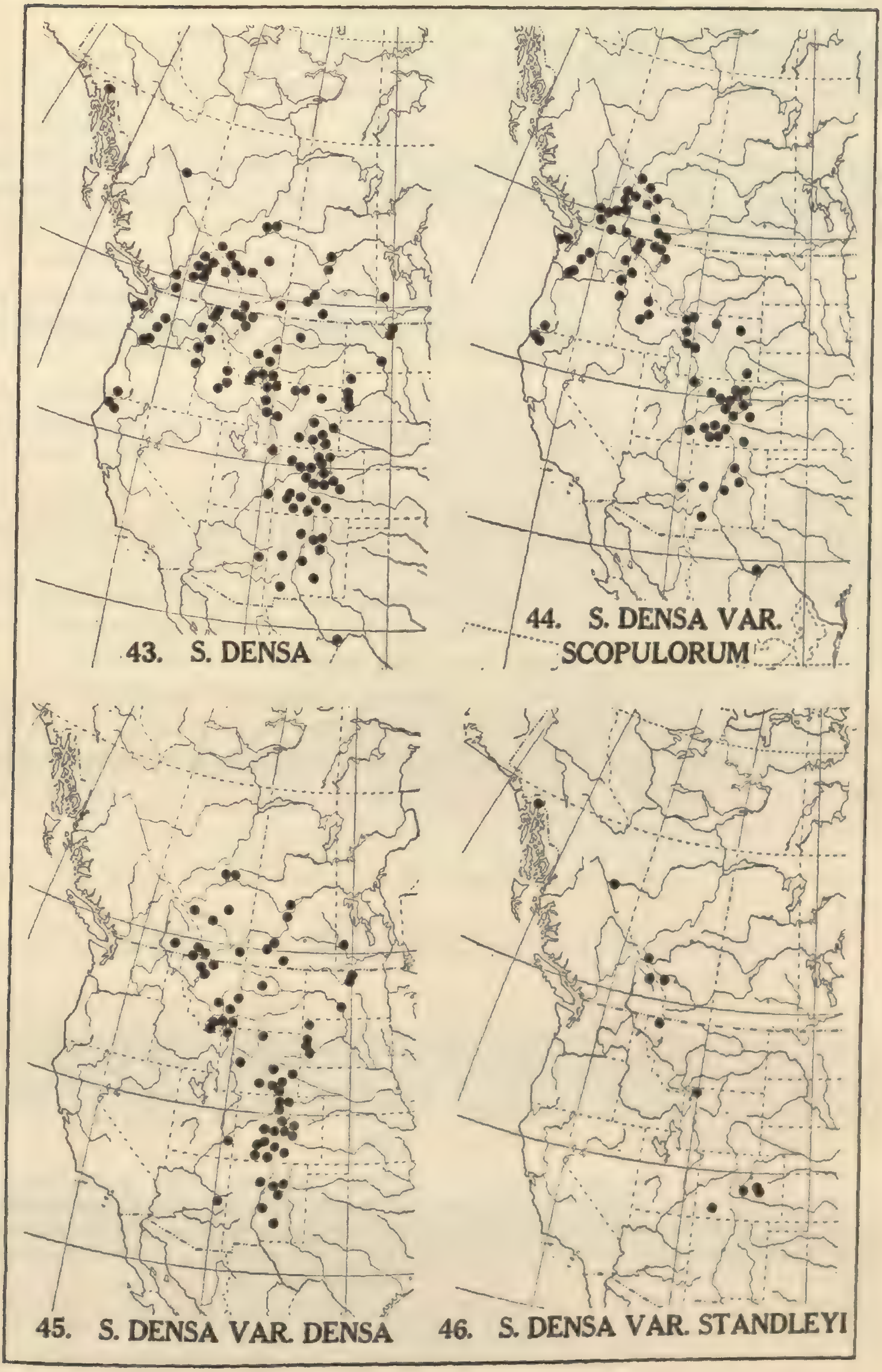
United States. montana: *Standley 15318a* (US), *15598* (US), vicinity of Cracker Lake, Glacier National Park, 1740–1920 m., July 15, 1919, *Standley 15732* (US), *Standley 16216* (US), *16255* (US), *16288* (US), *16378* (US), *17055* (US), *17164a* (US), *17979* (US), *18050* (US), *18185* (US); Aug. 25, 1917, *Ulke* (US); *Umbach 856* (F, MIN, NY, US). wyoming: *Goodding 483* (F, GH, MO, NY, US); *Mearns 4274* (US); *Merrill & Wilcox 1218* (GH, NY, US). colorado: *Cox 290* (F, MO); *Murdoch 4787* (F, US). utah: *E. B. & L. B. Payson 4037* (GH, MO). texas: *Moore & Steyermark 3245* (US). new mexico: *Metcalfe 1172* (BM, F, GH, MIN, MO, NY, US). arizona: 1913, *Ferriss* (US). idaho: *Epling 7033* (F, MO, US). washington: *Flett 3092* (US); *Suksdorf 8834* (GH, MO, NY, US). oregon: *Ferris & Duthie 941* (US); *Maguire & Holmgren 27132* (GH, NY, US). california: *J. T. Howell 13521* (US); *L. C. Wheeler 3036* (US).

33b. Selaginella densa var. **densa.** Figs. 44, 45, 47. Map 45.

Selaginella longipila Hieron. in Hedwigia 39:291. Dec. 28, 1900. (Lectotype: *Bourgeau* in 1858 (Herb. Kew Exsicc. no. 1239, wrongly labeled "Himalaya") B!. Paratype: "*Herb. Griffith,* Bhotan" B! fragment NY!, collector and locality unknown).

Selaginella rupestris (L.) Spring f. *longipila* A. Br. ex Hieron. in Hedwigia 39:291. 1900, in synon.

Selaginella Engelmannii Hieron. in Hedwigia 39:294. Dec. 28, 1900. (Holotype: *Engelmann* B!).


43. S. DENSA
44. S. DENSA VAR. SCOPULORUM
45. S. DENSA VAR. DENSA
46. S. DENSA VAR. STANDLEYI

Selaginella Haydenii Hieron. in Hedwigia 39:296. Dec. 28, 1900, as *Haydeni.* (Lectotype: *Hayden* B!. Paratype: *Lyall* B! fragment NY!).
Selaginella rupestris var. *densa* (Rydb.) Clute, Fern Allies, 142. 1905.
Selaginella rupestris f. *Engelmannii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.
Selaginella rupestris f. *Haydenii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Apex of leaves plane to abruptly beveled in profile; setae milk-white and opaque to whitish and subopaque. Sporophylls with the cilia dentiform to piliform and ascending, rarely laxly ascending, toward the apex; apex plane to abruptly beveled in profile.

The misapplication of *S. longipila* to the Himalayan *S. indica,* because of a mixture of labels has been discussed under *S. indica.* The type specimens are actually *S. densa* var. *densa* but fortunately Rydberg's well-known name has a few months priority.

Intermediates with var. *scopulorum* are mentioned under that variety and specimens of var. *Standleyi* that show a tendency toward var. *densa* are mentioned under var. *Standleyi.*

Specimens that are intermediate with var. *Standleyi* are such as: Colorado, Aug. 26, 1896, *Holm* (MO), Sept. 12, 1905, S. *Shaw* (GH), July 6, 1937, *Wherry* (US).

Specimens of var. *densa* that show a tendency toward var. *scopulorum* are such as: Colorado, *F. E. & E. S. Clements 532* (GH,MO,NY,US); New Mexico, *Arsène & Benedict 15877* (F, US), *Fendler 1025* (BM, GH, MO).

An example of var. *densa* with a tendency toward var. *Standleyi* is: Empire, Colorado, Aug. 27, 1874, *Engelmann* (B, MO, US).

The following specimens are rather intermediate between all three varieties: Wyoming, *Hermann 4665* (MO); Colorado, *Ewan 12699* (Ewan); New Mexico, *Arsène & Benedict 18056* (F).

Prairies, alpine meadows or dry rocky places, acidic rocks or sandy soil, 1100–4000 m.

Southeastern Manitoba to British Columbia, south to New Mexico and Arizona.

Representative specimens:

Canada. manitoba: *Macoun & Herriot 70373* (F, GH, NY). saskatchewan: *Boivin & Gillett 8686* (MO); Fort Carlton, March 29, 1858, *Bourgeau* (Herb. Kew Exsicc. no. 1239) (B, NY, P, US, YU); *Cowles 43* (F, MO); *Gillett 6022* (MO). alberta: *Breitung 5553* (MO); S. *Brown 128* (GH, MO, US); *Malte & Watson 1229* (GH). british columbia: *Calder & Savile 7677* (MO), *9221* (MO).

United States. "Oregon", 49 N. Lat., 1858–59, *Lyall* (B, NY). north dakota: Aug. 12, 1908, *Lunell* (GH, MIN, US), Sept. 10, 1908 (NY, US). south dakota: Black Hills, 1853–54, *F. V. Hayden* (B, MO, NY, US); *Hayward 315* (F, NY). montana: Little Rocky Mountains, Sept. 1889, *Havard* (NY, US); *Newberry* (NY); *Rydberg & Bessey 3517* (F, GH, MIN, NY, US); *R. S. Williams 534* (US). wyoming: *A. Nelson 8781* (F, GH, MO, NY, US). colorado: *Johnston 3896* (US), *3897* (US), *3898* (US); *Rydberg & Vreeland 6590* (NY); *L. & R. Williams 2126* (GH, MO).

√33c. SELAGINELLA DENSA var. **Standleyi** (Maxon) Tryon, comb. nov.

Fig. 46. Map 46.

Selaginella Standleyi Maxon, in Smiths. Misc. Coll. 72^5:9. 1920. (Holotype: *Standley 17228* US!. Paratypes: *Brown 95* US!; *Standley 15363* US, *16970* US!, *17483* US!, *18136* US!; *Ulke* on Aug. 25, 1917 US!).

Apex of leaves predominantly or entirely truncate in profile; setae whitish- to greenish-lutescent to lutescent, translucent. Sporophylls eciliate or with the cilia dentiform or piliform and ascending toward the apex; apex truncate, rarely abruptly beveled in profile.

Intermediates of var. *Standleyi* and var. *densa* and material of var. *densa* with a tendency toward var. *Standleyi* are mentioned under var. *densa*. Specimens of var. *scopulorum* with a tendency toward var. *Standleyi* are mentioned under var. *scopulorum*.

Specimens of var. *Standleyi* with a tendency toward var. *densa* are such as: Montana, *Standley 16970* (US), *Van Schaack 2786½* (MO); Colorado, *Johnston 3899* (GH).

Specimens intermediate between var. *Standleyi* and var. *scopulorum* are: Montana, Aug. 11, 1931, *J. H. Schaffner* (BM); Colorado, *Underwood & Selby 133* (NY), *Vasey* (MO).

Rocky alpine meadows, dry rocky slopes and cliffs, acidic rocks, 1500–4660 m.

Southern Alaska to Colorado.

Representative specimens:

ALASKA: *A. & A. Krause 162* (B).

CANADA. ALBERTA: *S. Brown 95* (GH, MO, US). BRITISH COLUMBIA: Aug. 30, 1904, *Holway & Butters* (MIN, US); *Raup & Abbe* (GH, NY).

UNITED STATES. MONTANA: *Barkley 1725* (GH, MO, US); *Standley 15363* (US), vicinity of Sexton Glacier, Glacier National Park, Aug. 7, 1919, *Standley 17228* (US), *Standley 17483* (US), *18136* (US); Aug. 25, 1917, *Ulke* (US). COLORADO: *Johnston 3903* (NY, US).

34. SELAGINELLA SIBIRICA (Milde) Hieron. in Hedwigia 39:290. 1900.

Fig. 48. Map 47.

Selaginella rupestris (L.) Spring f. *sibirica* Milde, Fil. Europ. Atlant. 262. 1867. (Lectotype: Unalaska, *Chamisso*. Paratypes: Ajan, *Tilling*; Dahuria ad flumen Ingoda, *Pallas*).

Selaginella rupestris f. *amurensis* Milde, Fil. Europ. Atlant. 262. 1867. (Holotype: Amur, *Maximowicz*).

Selaginella rupestris f. *manchuriensis* Milde, Fil. Europ. Atlant. 262. 1867. (Holotype: Khalkyli, *Maack*).

Selaginella Schmidtii Hieron. in Hedwigia 39:292. 1900. (Lectotype: *Schmidt* B! fragment NY!. Paratype: *Chamisso* B! fragment NY!).

Selaginella Schmidtii var. *Krauseorum* Hieron. in Hedwigia 39:293. 1900. (Lectotype: *A. & A. Krause 53* B! fragment NY!. *A. & A. Krause 162* B! is excluded as a type; it is S. *densa* var. *Standleyi*).

Selaginella rupestris f. *Schmidtii* (Hieron.) Clute, in Fern Bull. 16:52. 1908.

Stems long to moderately long, forming open, spreading mats; branches long and remote to moderately short and subapproximate, intricate, not fragmenting when dry. Upper and under leaves equal or subequal in length, or the under

slightly longer, on the same portion of the stem; leaves linear to ligulate-long-triangular; base usually glabrous, less often pubescent, that of the upper leaves adnate to the stem for 1/6 their length; margins ciliate, the cilia spreading to laxly ascending toward the apex; apex of the upper leaves fleshy, broadly rounded to carinate, subtruncate to usually truncate in profile; setae forming conspicuous tufts at the dry branch-tips, 1/3 to 3/5 as long as the blade, scabrous, milk-white to white to tawny, opaque to translucent. Sporophylls eciliate or with the cilia piliform to dentiform and ascending toward the apex, the broadest 3 to usually 4 times as broad as the leaves; seta base usually strongly broadened and flattened. Megaspores rugose to rugose-reticulate, pale yellow to pale orange.

The Alaskan and Yukon material is relatively uniform while that from Asia is less so. In addition to the typical form with short, milk-white setae a phase occurs in Asia with longer and tawny setae, and also occasional specimens bear strobili having 1 to 2 megaspores in a sporangium. This is quite parallel with S. *densa* var. *densa,* the reduced number of megaspores being so rare that it is not possible to be certain of apogamy.

S. *sibirica* is most similar to S. *densa* var. *Standleyi* from which it may be separated by the white to tawny rather than lutescent setae and the intricate rather than discrete branches. It is separated from S. *shakotanensis,* which also grows in Japan, by the leaf-bases that place the two in different series. The seta length likewise distinguishes these species—in S. *sibirica* they are 1/3–3/5 as long as the blade while in S. *shakotanensis* they are 1/5 as long.

The only sporelings observed in this study were seen in the soil of a mat of S. *sibirica* collected by Calder & Billard (*2995* MO). These are discussed in some detail in the introduction.

Dry, rocky, open places or on cliffs, 130–2400 m.

Yukon and Alaska to Trans Baikal, Manchuria and Japan.

Representative specimens:

Canada. yukon: *Calder & Billard 2995* (MO), *4454* (MO), *4601* (MO, US); *Tarleton 188* (NY, US).

Alaska: unalaska, *Chamisso* (B, NY); *Flett 1529* (NY, US); *A. E. & R. T. Porsild 690* (GH, MO, US); *Scamman 1981* (GH, MO).

Behring Straits: Emma Harbour, Sept. 21, 1881, *A. & A. Krause 53* (B, NY); *C. Wright* (GH, NY, US, YU).

Union of Soviet Socialist Republics. kamtchatka: *Eyerdam* (F); *Novogablenov 541* (US). sachalin: *Fr. Schmidt* (B, GH, NY, US). trans baikal: Ingoda river (Dahuria), *Fischer* (GH, P).

Japan: *Faurie 1100* (P), *7279* (P), *8496* (MO, P), *9687* (MO, P), *13903* (P).

35. Selaginella Watsonii Underw. in Bull. Torr. Bot. Club 25:127. 1898, as *Watsoni.* (Holotype: *Watson* in 1869 NY!. Paratypes: *Watson* in 1868 NY!; *Hansen 879* NY!; *Coville & Funston 2071* NY!; *Brewer 2103* NY!).

Figs. 49–51. Map 48.

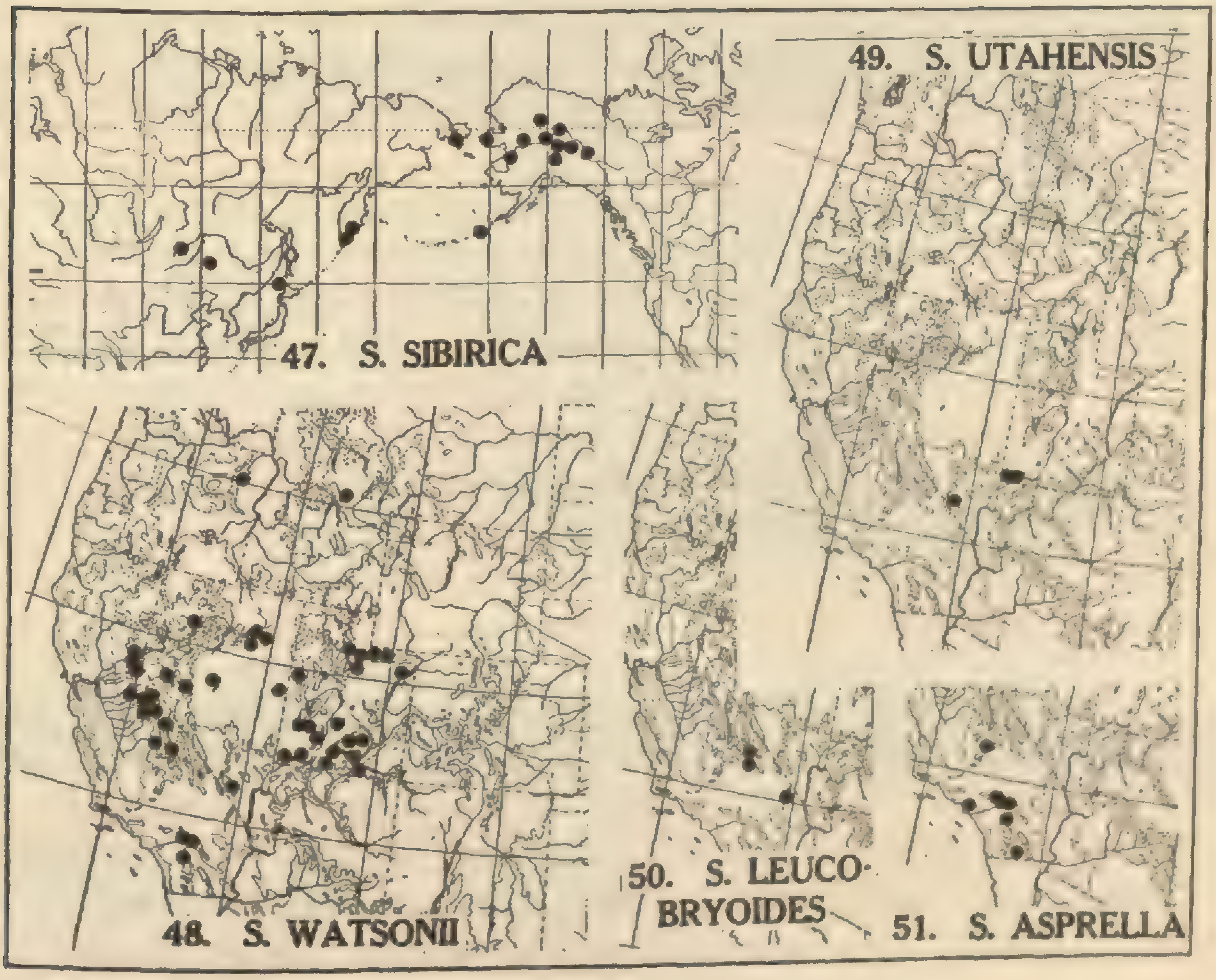
Stems short to moderately long, forming rounded cushion mats; branches short, subapproximate to moderately long and remote, intricate, not readily fragmenting when dry but rather easily broken by hand. Upper and under leaves equal in

length, or the under slightly longer, on the same portion of the stem; leaves ligulate to broadly ligulate to ligulate-long-triangular; base glabrous to slightly pubescent, that of the upper leaves adnate to the stem for ⅕ to ⅓ their length; margins eciliate, rarely with ascending cilia toward the apex; apex of the upper leaves fleshy, narrowly to broadly carinate, subtruncate to truncate in profile; setae not or hardly forming conspicuous tufts at the dry branch-tips, ⅕ to ¼, rarely ⅓, as long as the blade, usually smooth, sometimes slightly scabrous, greenish-white to greenish-lutescent to whitish-lutescent, translucent to subopaque. Sporophylls eciliate toward the apex, the broadest about 2 times as broad as the leaves. Megaspores rugose to rugose-reticulate, pale orange.

S. *Watsonii* is characterized by its fleshy leaves which are usually eciliate and short-setate. In habit it forms dense rounded mats with intricate branches. The fragile nature of the stem of the next three species is poorly developed in S. *Watsonii.* The stems can be easily broken by hand but specimens do not fragment in packets or with ordinary handling. It seems probable that the next three species have been derived from S. *Watsonii* or a common ancestor.

Exposed or shaded cliffs, talus slopes or rocky alpine meadows, in crevices or on boulders or among rocks, usually related to igneous rocks, rarely to limestone, 1800–4300 m., usually 3000–3700 m.

Southwestern Montana to northeastern Oregon, south to Utah and southern California.



Representative specimens:

United States. montana: *T. D. Howe 66* (US). utah: *G. J. Goodman* (GH, MO, NY, US); *M. E. Jones 1246* (NY, US); *Maguire & Richards 13166* (GH, MO); *E. B. & L. B. Payson 4917* (GH, MO, US), *5074* (GH, MO, NY, US); *Rydberg & Carlton 6566* (GH, NY, US); Cottonwood Cañon, 9500 ft., July, 1869, S. *Watson 1370* (NY, YU). nevada: *Heller 11054* (F, GH, MO, NY, US); *Maguire 21090* (GH, NY, US); Sept., 1868, S. *Watson 1370* (NY, US). oregon: July 1, 1931, *Wherry* (US). california: *Brewer 2103* (NY, YU); *Coville & Funston 2071* (NY, US); Sept. 5, 1923, *C. C. Hall* (F, MO, NY, US); *Hansen 879* (BM, MO, NY, US); *Heller 7167* (GH, MO, NY, US); *R. M. & A. F. Tryon 5060* (ARIZ, B, BM, CU, DS, F, FI, GH, K, MICH, MIN, MO, NY, P, PH, POM, RM, UC, US, WS).

36. Selaginella utahensis Flowers, in Amer. Fern Jour. 39:83. 1949. (Holotype: *Cottam 5644* UT fragment US!. Paratype: *Cottam 8817* UT).
Fig. 52. Map 49.

Stems moderately short, forming rounded to flat cushion mats; branches moderately short to moderately long, approximate to nearly remote, intricate, readily fragmenting when dry. Upper and under leaves equal or subequal in length on the same portion of the stem; leaves subulate to ligulate-lanceolate to ligulate-long-triangular; base usually glabrous, sometimes pubescent, that of the upper leaves adnate to the stem for ¼ their length; margins eciliate to ascending-ciliate toward the apex; apex of the upper leaves slightly fleshy, broadly carinate, gently to rather abruptly beveled in profile; setae not forming conspicuous tufts at the dry branch-tips, less than ⅕ as long as the blade to essentially absent, smooth, whitish to greenish- to lutescent-whitish, subopaque. Sporophylls eciliate or with the cilia dentiform and strongly ascending toward the apex, the broadest 2 to 3 times as broad as the leaves. Megaspores slightly rugose-reticulate to slightly rugose, yellow-orange.

S. *utahensis* may be separated from the next two species, that also share the character of readily fragmenting stems, by its leaves which are muticous or have short, smooth setae. The anatomical basis of the fragmenting stems has not been investigated. In mounted material the parts will be held together if glue or soil holds the roots and rhizophores firmly but in packets or in unmounted material ordinary handling of the sheet will soon reduce the stems to small pieces.

Ledges and crevices of sandstone cliffs, 1500–2300 m.

Southern Nevada and southwestern Utah.

Specimens examined:

United States. utah: Lady Mountain, Zion National Park, 6,500 ft., April 5, 1931, *W. P. Cottam 5644* (MO, US); *Degener & Peiler 16982* (NY); *Eastwood & Howell 1159* (US); *Flowers 3249* (MO). nevada: June 28, 1930, *E. Jaeger* (US).

37. Selaginella leucobryoides Maxon, in Smiths. Misc. Coll. 72^5:8. 1920. (Holotype: *Munz & Harwood 3789* US!. Paratypes: *Coville & Funston 628* US!; *Munz, Johnston & Harwood 4226* US!). Fig. 53. Map 50.

Stems short, forming flat or rounded cushion mats; branches short, approximate, intricate or discrete, readily fragmenting when dry. Upper and under leaves

equal in length, or the under slightly longer, on the same portion of the stem; leaves linear to ligulate-ovate; base glabrous to pubescent, that of the upper leaves adnate to the stem for ¼ or less their length; margins eciliate to ascending-ciliate toward the apex; apex of the upper leaves herbaceous, slightly to broadly rounded, gently to abruptly beveled in profile; setae not forming conspicuous tufts at the dry branch-tips, ⅕ or less as long as the blade, scabrous to slightly scabrous, milk-white and opaque, rarely white and translucent. Sporophylls eciliate or with the cilia dentiform and ascending toward the apex, the broadest about 3 times as broad as the leaves. Megaspores slightly rugose to rugose-reticulate, to nearly smooth on the outer face, pale orange.

The short, white, scabrous and usually opaque setae are characteristic of *S. leucobryoides.* It shares the peculiar character of fragile stems with S. *utahensis* and S. *asprella.*

Rocky slopes, in crevices or among rocks, 900–2300 m.

Southeastern California.

Specimens examined:

UNITED STATES. CALIFORNIA: *Coville & Funston 628* (NY, US); *Coville & Gilman 111* (US); *J. T. Howell 3989* (F, GH, MO, US); Bonanza Mine, Providence Mountains, 2800 ft., March 30, 1920, *P. A. Munz & R. D. Harwood 3789* (F, GH, NY, US); *Munz, Johnston & Harwood 4226* (US).

38. SELAGINELLA ASPRELLA Maxon, in Smiths. Misc. Coll. 72^5:6. 1920. (Holotype: *Johnston 1815* US!. Paratypes: *Johnston 1595* US!, *1807* US!).

Fig. 54. Map 51.

Stems short to moderately short, forming rounded or flat cushion mats; branches moderately short and remote to short and subapproximate, intricate, rather readily fragmenting when dry. Upper and under leaves essentially equal in length on the same portion of the stem; leaves linear-lanceolate to lanceolate-ovate to lanceolate-long-triangular; base pubescent, rarely glabrous, that of the upper leaves adnate to the stem for about ⅓ their length; margins eciliate to ascending-ciliate toward the apex; apex of the upper leaves herbaceous, broadly rounded to carinate, nearly plane to truncate in profile; setae forming conspicuous tufts at the dry branch-tips, ⅓ to over ½ as long as the blade, scabrous, white and translucent to rarely milk-white and opaque. Sporophylls eciliate or with the cilia piliform to dentiform and strongly ascending toward the apex, the broadest about 3 times as broad as the leaves. Megaspores prominently and coarsely rugose-reticulate, most prominently marked in the equatorial region, pale yellow to pale orange.

S. *asprella* is characterized by its long, scabrous, white, usually translucent setae. Of the three species with readily fragmenting stems, it is the furthest removed from the presumed ancestor, S. *Watsonii.*

Open areas in rocky soil or in crevices at the base of boulders, igneous rock, 1800–2700 m.

Southern California.

Specimens examined:

United States. california: *J. T. Howell 5031* (US); *Jaeger 276* (US); *I. M. Johnston 1595* (MO, US), *1807* (MO, US), West end of Ontario Peak, San Antonio Mountains, 6000 ft., March 25, 1918, *I. M. Johnston 1815* (MO, US); *Munz 7612* (NY), *9683* (US), *17165* (GH); Sept. 14, 1921, *Saunders* (US); April, 1906, *Streeter* (NY, US); *R. M. & A. F. Tryon 5059* (ARIZ, B, BM, CU, DS, F, FI, GH, K, MICH, MIN, MO, NY, P, PH, POM, RM, UC, US, WS).

Series **Eremophilae** Tryon, ser. nov.

Rhizomata et stolones et gemmae nulla. Caules prostrati. Apices ramorum involuti statu inerte. Caules frondosi valde dorsiventrales. Folia supera base abrupte adnata caule distincta colore, folia infera base valde decurrente. Typus: *Selaginella eremophila* Maxon.

Plants terrestrial; rhizomes, stolons and basal buds absent. Stems prostrate or assurgent at the branch tips, with rhizophores produced generally throughout; stems long to rather short, forming open or usually rather compact, rounded or usually flat mats. Branches moderately long to short, remote to subapproximate, usually intricate, branch tips involute in the dormant state. Leafy stems strongly dorsiventral, the under leaves appressed, the upper erect, the under longer, usually thinner and different in shape from the upper; zone of green leaves much longer on the upper side of the stem, very short to absent on the under side. Upper leaves with the base abruptly adnate, distinct from the stem in color, under leaves with the base very strongly decurrent.

The species of *Eremophilae* form a homogeneous series and one in which there is increasing specialization in the dorsiventral habit. *S. peruviana* is strongly dorsiventral in position, length and shape of the upper and under leaves; in *S. arizonica* they are also different in texture. In *S. eremophila* the setae are highly specialized and the leaves of *S. Parishii* are muticous. Finally, in *S. Landii*, the under leaves are unusually long in relation to the upper and they are setate while the upper leaves are muticous. The species are all quite distinct with the exception of the first two, *S. peruviana* and *S. arizonica*, which are rather closely related.

KEY TO SPECIES

a. All leaves setate (sometimes only in the bud); under leaves less than twice as long as the upper. b.

  b. Setae mostly or entirely persistent, stout, straight. c.

    c. Under leaves subulate, acuminate, broadest at or very near the base, rarely linear-lanceolate, not appreciably thinner than the herbaceous upper leaves, setae 0.5–1.0 mm. long. Oklahoma to New Mexico; Mexico; Peru to Argentina .... 39. *S. peruviana*, p. 77

    c. Under leaves lanceolate to lanceolate-ovate, broadest above the base, papyraceous, the upper fleshy, setae 0.1–0.3 mm. long. Texas to Arizona; Baja California .... 40. *S. arizonica*, p. 78

  b. Setae mostly early-deciduous (sometimes present only in the bud), delicate, filiform, tortuous .... 41. *S. eremophila*, p. 80

a. Upper leaves, or all leaves muticous. d.
   d. All leaves muticous; under leaves about twice, or less, as long as the upper; upper leaves lanceolate to lanceolate-triangular....42. S. *Parishii*, p. 80
   d. Upper leaves muticous; under leaves predominantly short-setate, the setae persistent; under leaves over twice as long as the upper; upper leaves long-deltoid or with parallel sides toward the base 43. S. *Landii*, p. 81

39. Selaginella peruviana (Milde) Hieron. in Hedwigia 39:307. 1900.
Figs. 55, 56. Map 52.

Lycopodium ciliatum Ruiz ex Spring, in Nouv. Mém. Acad. Roy. Belg. 24 (Monog. Fam. Lycopod.):55. 1850, in synon. (evidently based on *Ruiz 98* B!).
Selaginella rupestris (L.) Spring f. *peruviana* Milde, Fil. Europ. Atlant. 263. 1867. (Holotype: *Ruiz 98* B!; the lower right-hand specimen of *Wilkes Exped. 1*, Peru, GH! is identical).
Selaginella rupestris var. *mexicana* Milde, Fil. Europ. Atlant. 263. 1867. (*Aschenborn 65* B! is so annotated by Milde or A. Br.).
Selaginella rupestris var. *peruviana* (Milde) Hieron. in Engl. Bot. Jahrb. 22:417. 1896.
Selaginella Aschenbornii Hieron. in Hedwigia 39:305. 1900. (Lectotype: *Aschenborn 65* B!; *Palmer 554* GH! and US! (62778) is identical. Paratypes: *Schaffner 10* B!; *Schaffner* vel *Sartorius* B; *Hahn* in 1868 B; Mexico City, *Schmitz* B; Toluta, *von Chrismar* B. Vancouver Island, *J. H. Henry* B should be excluded as a type; it is probably S. *Wallacei*).
Selaginella peruviana var. *Dombeyana* Hieron. in Hedwigia 39:308. 1900. (Lectotype: *Bang 111* B!. Paratypes: *Mandon 84* B!; *Dombey 14* B! sterile; Bolivia, March 20, 1892, O. *Kuntze* B; Argentina, *Hieronymus & Lorentz 162* B; Argentina, Jan. 1874, *Lorentz & Hieronymus* B).
Selaginella Sheldonii Maxon, in Proc. Biol. Soc. Wash. 31:171. 1918, as *Sheldoni*. (Holotype: *Sheldon 233* US!. Paratypes: *F. C. Greene* on June 10, 1918 US!, on May 4, 1918 US!; *Jermy 343* US!; *Havard* US!; *Wooton* US!).

Upper leaves herbaceous, or fleshy only at the base, linear, acuminate, to linear-long-triangular; under leaves herbaceous, subulate, acuminate, broadest at or very near the base, to rarely linear-lanceolate, a little longer than the upper on the same portion of the stem; leaves setate in the bud, setae persistent (part may be abraded), stout, straight, those of the under leaves 0.5–1.0 mm. long, rarely some 0.3 mm. long. Megaspores rather coarsely rugose-reticulate on the commissural face, less prominently marked on the outer face, yellow to bright orange.

S. *peruviana* is the least specialized member in the series and for this reason it is considered as the basic type. Some four collections of the many examined (*Stanford et al. 118* MO, *Steyermark 52276* F, *Arsène 7087* US, *Sharp 44257* US) show a tendency toward S. *arizonica* in having either relatively thin under leaves or short (0.2–0.3 mm.) setae. The primary characters of S. *peruviana* are the narrow under leaves, the long setae and the similar texture of the upper and under leaves.

The localities taken from the literature (map 52) are from Alston, in Physis 15:253. 1939.

Bluffs, rocky slopes or on ledges and in crevices of cliffs, exposed or under light shade, igneous rocks or sandstone, less often in sandy or clay soil, 600–3000 m. in the United States, 1300–3200 m. in Mexico and 1900–4000 m. in South America.

Oklahoma and New Mexico to Puebla; Peru to Argentina.

Representative specimens:

United States. oklahoma: *Goodman 2337* (GH, MO, NY, US); May 4, 1918, *F. C. Greene* (US), June 10, 1918 (US); Quanah Mountain, Indian Territory, July 28, 1891, *Sheldon 233* (US). texas: July, 1883, *Havard* (US); *Jermy 343* (MO, US); *Lindheimer 77* (GH, MO, US); *C. H. Mueller 8256* (GH, MO, NY, US); *R. M. & A. F. Tryon 5032* (BM, CU, DS, GH, MIN, MO, PH, POM, US, WS); March 7, 1918, *Wooton* (US). new mexico: *Arsène 18050* (F, US), *18613* (F, US); *Arsène & Benedict 16838* (F, US).

Mexico. *Aschenborn 65* (B). coahuila: *Stanford et al. 118* (GH, MO, NY, US). chihuahua: *E. Palmer 38* in 1908 (GH, US). durango: *E. Palmer 554* in 1896 (GH, US). mexico: *Schaffner 933* (GH, YU). distrito federal: *Schaffner 10* (B, BM).

Peru: *Cook & Gilbert 158* (US), *240* (US), *305* (US), *608* (US); *Dombey 14* (B, P); *Soukup 1885* (GH, US), *3571* (MO); *Stork & Horton 9388* (F); Huanuco, *Ruiz 98* (B, P); *Vargas 3141* (F), *11058* (F).

Bolivia: Vicinity of La Paz, 10,000 ft., 1889, *Bang 111* (B, F, GH, K, MO, P, US); *Buchtien 4299* in 1919 (F, MO, US); *Eyerdam 24798* (F); *Mandon 84* (B), *1531* (B).

Argentina: *Burkart 10112* (MO); *Hieronymus & Lorentz 162* (P); *Lossen 426* (F, MO).

40. Selaginella arizonica Maxon, in Smiths. Misc. Coll. 72^5:5. 1920. (Holotype: *Shreve* US!. Paratypes: *Thornber 315* US!; *Cook* US!; *Parish 8513* US!; *P. F. Mohr* US!; *Toumey* US!; *Goodding 722* US!; *Bailey* in 1913 US!, on Nov. 9, 1913 US!). Figs. 57, 58. Map 53.

Upper leaves fleshy, lanceolate to linear-lanceolate; under leaves papyraceous, lanceolate to lanceolate-ovate, broadest above the base, about as long as to slightly longer than the upper on the same portion of the stem; leaves setate in the bud, setae predominantly (or many) persistent, stout, straight, those of the under leaves 0.1–0.3 mm. long. Megaspores rather finely rugose-reticulate on the commissural face, less prominently marked on the outer face, pale orange.

S. *arizonica* is characterized by its short setae and thin and broad under leaves. It is rather closely related to S. *peruviana* and some specimens of that species approach S. *arizonica* in having relatively thin under leaves or short setae. In Texas the two sometimes grow in the same mat but these mixtures are readily separable. Some strobili of *A. & R. A. Nelson 1158* MO have vegetative growth beyond the tip, a condition not uncommon in S. *arenicola* ssp. *Riddellii.*

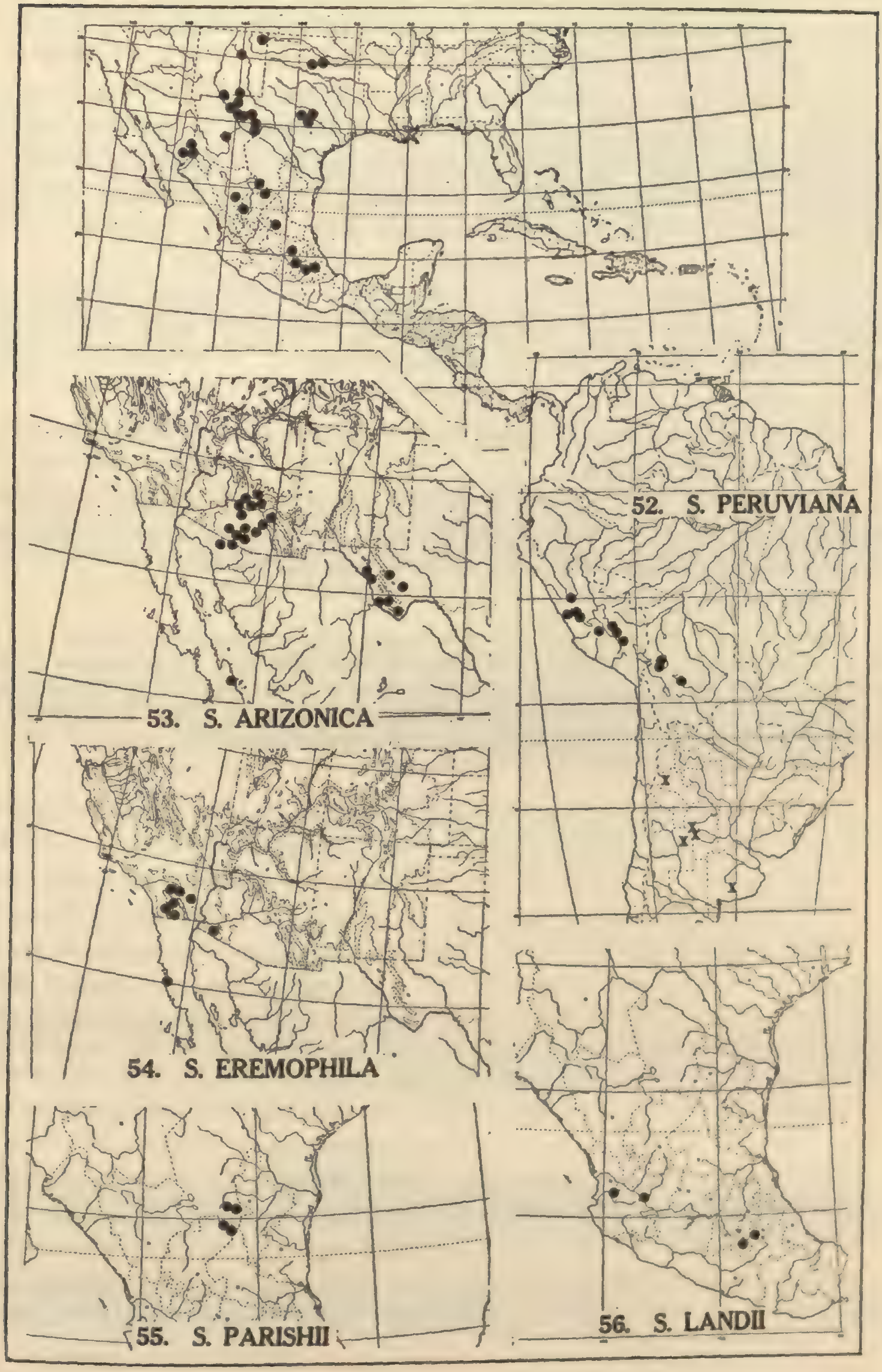
Exposed rocky places, in crevices or on ledges, or in gravel, usually on igneous rock, rarely on limestone, 600–2000 m.

Southwestern Texas, Arizona and adjacent Sonora, Baja California.

Representative specimens:

United States. texas: *Cory 6878* (GH), *40232* (GH, US); *Hinckley 2147* (GH); June 6, 1924, *Orcutt* (GH, US); *R. M. & A. F. Tryon 5048* (ARIZ, FI, MICH, MO, PH, POM, RM). arizona: Nov. 9, 1913, *V. Bailey* (US), 1913, *V. Bailey* (US); 1913, *O. F. Cook* (US); *Goodding 722* (GH, NY, US); April, 1873, *P. F. Mohr* (US); *Nelson 11217a* (GH, NY, US); *Parish 8513* (US); *Phillips 2930* (GH, MO, US); Foot of Soldier Trail, Santa Catalina Mountains, July 28, 1914, *Shreve* (GH, MO, NY, US); *Thornber 315* (US); April 3, 1894, *Toumey* (US); *R. M. & A. F. Tryon 5052* (B, BM, F, GH, K, MO, NY, P, UC, US).

Mexico. sonora: *Mearns 2701* (B, US); *Wiggins 8330* (US). baja california: Oct. 26, 1930, *M. E. Jones* (BM, MO, US).


52. S. PERUVIANA
53. S. ARIZONICA
54. S. EREMOPHILA
55. S. PARISHII
56. S. LANDII

41. Selaginella eremophila Maxon, in Smiths. Misc. Coll. 72^5:3. 1920. (Holotype: *Johnston 1047* US!. Paratypes: *Mearns 3162* US!; *Bethel* US!; *Saunders* in 1908 US!; *Hall* US!; *Parish 6111* US!; *Dudley* US). Fig. 59. Map 54.

Upper leaves fleshy, lanceolate-triangular to ligulate-triangular; under leaves papyraceous, to herbaceous at the apex, ligulate-lanceolate to lanceolate-ovate, about as long as to half again as long as the upper on the same portion of the stem; leaves setate in the bud, setae entirely deciduous to casually persistent, delicate, filiform, tortuous. Megaspores rugose-reticulate with irregularly projecting rugae on the commissural face, rugose-reticulate on the outer face, pale yellow.

The tortuous, delicate and early deciduous setae set this species off from all others. The setae are attached only on the young leaves in the apical bud and are so inconspicuous that they had been overlooked until C. A. Weatherby[24] noted them in 1943.

Jaeger in 1934, Arizona, is unusual in that the setae are only slightly tortuous and less delicate than normal.

Open rocky and sandy deserts, in sheltered places in rock crevices or in sand or gravel at the base of boulders, 130–1000 m.

Southwestern Arizona, southern California, Baja California.

Representative specimens:

United States. arizona: Dec. 17, 1934, *Jaeger* (US). california: April 17, 1918, *Bethel* (US); Dec. 25, 1903, *Dudley* (US); March, 1919, *Hall* (US); Palm Canyon (Palm Springs), Riverside Co., *Johnston 1047* (US); *Mearns 3162* (NY, US); *Parish 1200* (NY); *Rose 45342* (MO); 1903, *Saunders* (NY), 1908, *Saunders* (US); *R. M. & A. F. Tryon 5057* (B, BM, F, GH, MO, NY, P, UC, US); *Wolf 8461* (GH).

Mexico. baja california: *Wiggins 9981* (US).

42. Selaginella Parishii Underw. in Bull. Torr. Bot. Club 33:202. 1906. (Holotype: *Palmer 306* NY. *Parish 1200* and *Saunders* in 1903, also cited by Underw., were excluded by Maxon, in Smiths. Misc. Coll. 72^5:4. 1920; they are S. *eremophila*. Figs. 60, 61. Map 55.

Upper leaves fleshy, lanceolate to lanceolate-triangular; under leaves papyraceous, lanceolate-ovate, up to about twice as long as the upper on the same portion of the stem; leaves muticous, the slightly modified apex acute to obtuse. Megaspores rugose-reticulate with irregularly projecting rugae on the commissural face, rugose-reticulate on the outer face, pale yellow.

The muticous leaves are sufficient to set this species off from the others of the series. In a few specimens some strobili are dorsiventral.

Crevices of sandstone or slate rocks, 1700–2300 m.

Coahuila and adjacent Zacatecas.

Specimens examined:

Mexico. coahuila: *Nil 105 (Arsène 3453)* (US); June, 1909, *Nil* (US); *Pennell 17272* (US). zacatecas: *Chaffey 58* (US); near Concepción del Oro, *E. Palmer 306* in 1904 (F, GH, MO, US).

---

[24] Amer. Fern Jour. 33:115. 1943.

43. Selaginella Landii Greenm. & Pfeiff. in Ann. Mo. Bot. Gard. 5:205. 1918. (Holotype: *Barnes & Land 2024* MO!). Figs. 62, 63. Map 56.

Upper leaves fleshy, long-deltoid, or with parallel sides toward the base; under leaves papyraceous, lanceolate-ovate to ovate, acuminate, more than twice to 2½ times as long as the upper on the same portion of the stem; leaves muticous to short-setate, the upper muticous with the slightly modified apex obtuse, the under muticous or usually with a short, stout seta up to 0.3 mm. long. Megaspores slightly and finely rugose on the commissural face, slightly rugose, granular, to nearly smooth on the outer face, yellow-orange.

This is the most specialized species of the series in that it is the most strongly dorsiventral. The short-setate under leaves and the muticous upper leaves are sufficient to characterize it.

Dry rocks and on boulders, 1700–4000 m.

Nayarit to Puebla.

Specimens examined:

Mexico. nayarit: *M. E. Jones 23495* (MO, US). jalisco: *Barnes & Land 153* (F), San Estebán Mountains, ca. 32 km. from Guadalajara, 1908, *Barnes & Land 2024* (GH, MO, US); *Pringle 10823* (GH, US); *Rose & Painter 7499* (US). morelos: *Matuda 26352* (MO, US). puebla: *Kenoyer 25* (US).

DUBIOUS AND REJECTED NAMES

Lycopodium struthioloides Nutt. ex Baker, Handb. Fern Allies, 35. 1887, in synon., not Pr. 1825. The brief description is not sufficient to place this name although it suggests *S. Watsonii.*

Selaginella rupestris (L.) Spring var. *borealis* Spring, in Nouv. Mém. Acad. Roy. Belg. (Monog. Fam. Lycopod.) 24:57. 1850. Indirectly based on a variety of specimens representing many species.

Selaginella rupestris var. *brevipila* A. Br. in Ann. Sci. Nat. V, 3:270. 1865, in synon. Some of the specimens cited under the accepted name, *S. rupestris*, are *S. Sellowii*, others are *S. Sartorii.*

Selaginella rupestris var. *longipila* Fourn. Mex. Pl. 1:146. 1872, nomen nudum.

Selaginella rupestris var. *longipila* subvar. *glaucina* Fourn. Mex. Pl. 1:146. 1872, nomen nudum. *Wright 1820* is *S. Sellowii.* The other specimens cited undoubtedly represent other species.

Selaginella rupestris var. *longipila* subvar. *viridis* Fourn. Mex. Pl. 1:146. 1872, nomen nudum. *Bourgeau 2541* and *Bottéro 78* are *S. extensa;* the other specimens cited probably represent other species.

Selaginella rupestris var. *tropica* Spring, in Nouv. Mém. Acad. Roy. Belg. (Monog. Fam. Lycopod.) 24:57. 1850. Indirectly based on a variety of specimens representing many species.

Selaginella struthioloides (Presl) Underw. Bull. Torr. Bot. Club 25:132. 1898. (*Lycopodium struthioloides* Presl, Rel. Haenk. 1:82. 1825.)

Maxon (Amer. Fern Jour. 11:35–36. 1921) has discussed the misapplication of Presl's name by Underwood to *Selaginella oregana.* In addition to the characters of size mentioned by Maxon, I may add other reasons supporting his position. First, *Selaginella oregana* is not known to grow on Vancouver Island; the nearest station for it is about 160 miles south of Nootka Sound, the locality cited for *Lycopodium struthioloides.* Second, Presl would certainly have placed a specimen of *Selaginella oregana,* with its definite strobilus, under his heading "Spicis sessilibus" rather than under "Capsulis axillaribus" where he placed *Lycopodium struthioloides* and other species without strobili. Finally, Greville and Hooker, in Bot. Misc. 3:105. 1833, say of *Lycopodium struthioloides* Presl: "We have examined Haenke's specimen, named by Presl himself, in the Lambertian Herbarium; and find it to be in no respect different from *L. laxum* of that author, which also exists in the same collection." *Lycopodium laxum* is placed by Herter, Index Lycopod. 55. 1949, as a synonym of *Urostachys carinatus* (Desv.) Hert. (*Lycopodium carinatum* Desv.), a species of southeastern Asia. This evidently represents another example of a mixture of Haenke's labels.

LIST OF SPECIES

1. S. rupincola Underw.
   - 1a. S. × neomexicana Maxon
2. S. Bigelovii Underw.
3. S. arenicola Underw.
   - 3a. S. arenicola ssp. Riddellii (Van Eselt.) Tryon
     - 3a-b. Intermediate between ssp. Riddellii and ssp. arenicola
   - 3b. S. arenicola ssp. arenicola
     - 3b-c. Intermediate between ssp. arenicola and ssp. acanthonota
   - 3c. S. arenicola ssp. acanthonota (Underw.) Tryon
4. S. Balansae (A. Br.) Hieron.
5. S. Weatherbiana Tryon
6. S. viridissima Weath.
7. S. tortipila A. Br.
8. S. Sellowii Hieron.
9. S. Sartorii Hieron.
10. S. Wightii Hieron.
    - 10a. S. Wightii var. Wightii
    - 10b. S. Wightii var. Phillipsiana Hieron.
11. S. cinerascens A. A. Eaton
12. S. Arsenei Weath.
13. S. macrathera Weath.
14. S. shakotanensis (Franch. ex Takeda) Miyabe & Kudo
15. S. Wallacei Hieron.
16. S. mutica D. C. Eaton ex Underw.
    - 16a. S. mutica var. limitanea Weath.
      - 16a-b. Intermediate between var. limitanea and var. mutica
    - 16b. S. mutica var. mutica
17. S. extensa Underw.
18. S. Wrightii Hieron.
19. S. Steyermarkii Alston
20. S. Hansenii Hieron.
21. S. carinata Tryon
22. S. indica (Milde) Tryon
23. S. njamnjamensis Hieron.
24. S. caffrorum (Milde) Hieron.
25. S. echinata Baker
26. S. nivea Alston
27. S. proxima Tryon
28. S. Dregei (Presl) Hieron.

29. S. VARDEI Lév.
30. S. OREGANA D. C. Eaton
31. S. UNDERWOODII Hieron.
32. S. RUPESTRIS (L.) Spring
33. S. DENSA Rydb.
    33a. S. DENSA var. SCOPULORUM (Maxon) Tryon
        33a-b. Intermediate between var. SCOPULORUM and var. DENSA
        33a-c. Intermediate between var. SCOPULORUM and var. STANDLEYI
        33a-b-c. Intermediate between var. SCOPULORUM, var. DENSA and var. STANDLEYI
    33b. S. DENSA var. DENSA
        33b-c. Intermediate between var. DENSA and var. STANDLEYI
    33c. S. DENSA var. STANDLEYI (Maxon) Tryon
34. S. SIBIRICA (Milde) Hieron.
35. S. WATSONII Underw.
36. S. UTAHENSIS Flowers
37. S. LEUCOBRYOIDES Maxon
38. S. ASPRELLA Maxon
39. S. PERUVIANA (Milde) Hieron.
40. S. ARIZONICA Maxon
41. S. EREMOPHILA Maxon
42. S. PARISHII Underw.
43. S. LANDII Greenm. & Pfeiff.

INDEX TO EXSICCATAE

Abrams *3126* (2); *3399* (11); *3402* (2); *4716*, *5464* (20); *6296* (15); *6711*, *7355*, *7486* (2); *7723*, *10070* (20).
Abrams & McGregor *760* (35).
Abrams & Wiggins *207*, *341* (2).
Aguilar *1429* (19).
Alexander & Kellogg *2062* (2).
Allard *3570*, *4570b*, *4610a*, *5488*, *6475* (32).
Amable *1383* (39).
Amórtegui *A61* (9).
Anderson, A. P. *1894*, *1975* (7).
Anderson, J. P. *1427*, *5706* (34).
Andrieux *2* (9).
Anect *166* (39).
Antunes *543* (24).
Antunez & Dekindt *3040* (24).
Archer *6764*, *7129* (35).
Archer & Gehrt *118* (8).
Arechavaleta *472* (8).
Arsène *891* (8); *3453* (42); *9983* (12); *10205* (18); *10639* (8); *10640* (1); *10641* (12); *10642* (1); *10643* (12); *17777* (33a-b, 33b); *17817* (5); *17929* (5); *17930* (31); *17931* (5); *17945*, *17963*, *17972*, *17973*, *17974*, *17975*, *17976*, *17977*, *17978* (31); *17980* (5); *17982*, *18049* (31); *18050* (39); *18052* (31); *18342* (39); *18478* (31); *18613* (39); *18654*, *18666*, *19372*, *19377* (31); *20174* (39); *20985* (31); *20987*, *20988*, *20989*, *20990*, *20992* (39); *21107* (33a-b); *21118* (16b); *21120* (33a-b).
Arsène & Benedict *15872*, *15873*, *15874*, *15875* (31); *15876* (5); *15877*, *15878*, *16031*, *16033*, *16152* (33b); *16370* (33a-b); *16402* (33b); *16643* (16b); *16644* (33a); *16645*, *16838* (39); *16884* (31); *18053* (31); *18054* (33a-b); *18055* (33a); *18056* (33a, 33a-b-c).
Aubineau *25* (31).
Austin *241* (20).

Bachmann *9* (28).
Bacigalupi *1015* (16b); *2750* (15).
Baker, C. F. *2* (31); *16*, *2746* (15); *5234* (2).
Baker, M. F. *1*, *5* (3b).
Baldwin *5138* (32).
Balegno *959* (8).
Balls *6229* (8, 39).
Bang *111* (39).
Barber *65*, *68* (15).
Barclay *1568* (15).
Barkley *1725* (33a, 33c); *16144M* (18).
Barkley & Diettert *4802* (15).
Barnes & Land *153* (43); *233a* (1); *2024* (43).
Bartlett *808* (32); *10355* (9); *10529* (1); *10561* (18); *10876* (1); *11039* (9); *20456* (8).
Bartley & Pontius *167* (32).
Bartram *12* (40).
Beattie *5283* (15).
Beetle *1566*, *3066* (15).
Benedict *1* (31); *3* (5); *4*, *5*, *9*, *13*, *2285* (31).

Bergman *3156* (32).
Beyrich *198* (32).
Biltmore Herb. *3432a* (32); *3432b* (3c).
Blake, S. F. *544, 746, 916* (2); *3031, 4762* (32); *10088* (20); *10227* (35); *10351* (15); *11481A* (3c).
Blomquist *50* (3c).
Blomquist & Correll *4715, 4716* (7).
Bogusch *527* (1).
Boivin & Gillett *8686* (33b).
Bolander *4511* (20); *6247* (15).
Bosman *4651* (28).
Bottéro *78* (17).
Bottomley *2871* (28).
Boughton *N41* (39).
Bourgeau *2541* (17).
Brandegee, T. S. *672* (2).
Brass *14426, 14473, 14475* (3c).
Breitung *4024, 5553* (33b); *6010* (32).
Brewer *1597* (2); *1726, 2103* (35).
Brinkman *855* (33b).
Brown, S. *95* (33c); *128* (33b).
Buchholz *2* (39); *4* (16a).
Buchtien *3123, 4299* (39).
Bües *608* (8).
Burkart *809, 3308, 7128* (8); *10112* (39); *10113* (8).
Burkart & Troncoso *11174* (8).
Bush *174, 835, 2819, 4744, 5069, 5210, 5387* (32).
Butler *874* (15).
Butters & Abbe *172, 1044* (32).
Butters & Rosendahl *2136, 2955, 3352, 3595, 4278* (32).
Butters, et al. *398* (32); *592* (33a).

Cain *143* (33b).
Calder *2810* (32).
Calder & Billard *2995, 4454, 4601* (34).
Calder & Savile *7647, 7677* (33b); *7732* (15); *7945* (33a-b); *8072, 8366, 8540* (15); *9221* (33b); *10914, 11135, 11323, 11484, 11634* (33a).
Camp *74* (15); *1029* (35); *1231* (32).
Camp & Schulz *2525* (1).
Campbell & Canfield *531* (16b).
Cardenas *162* (39).
Carlson *1347a* (1).
Castetter *7487, 7488, 7492* (31); *7493, 7494* (33a-b); *7759* (31); *7947* (18); *8375* (33a-b); *8384* (16b).
Chaffey *58* (42).
Chaney *181* (32).
Chapman *3432b* (3c).
Chase, A. *1584, 1962* (32).
Chase, V. H. *318* (32); *7676* (18).
Cheney *3303* (32).
Chevalier *6668* (23).
Clark, O. M. *8968, 9628* (31); *10034* (40); *10036* (31).
Clausen *3674, 3679* (7).
Clausen & Trapido *3663* (32).
Clements, F. E. & E. S. *279* (31); *532* (33b).
Clokey *4849, 5164, 5165* (2).
Clokey & Anderson *6508, 6532* (2).
Colby *3364* (32).
Cole *5135* (32).
Conard *174* (30); *246* (15, 30); *1-930* (32).
Constance & Rollins *998* (15).
Cook & Gilbert *158, 240, 244, 248, 305, 608* (39).
Cooper, J. G. *462* (2).
Cooper, T. *662* (24).
Copeland *174* (18).
Core *3869* (32).
Correll *6169* (3c); *6615* (32); *6711* (7); *10857* (32); *13627* (6); *13804* (16b); *14994, 15000* (31); *15025, 15035* (1a); *15238* (3a).
Correll, D. S. & H. B. *7705* (32); *7897, 8012* (7).
Correll & McFarlin *6234* (3c).
Cory *888* (1); *4722* (3a); *6878* (40); *8444* (18); *9077* (39); *10294, 11650* (3a); *17616* (39); *18310* (18); *30143, 30331* (39); *30971* (18, 39); *38235, 38438, 39454* (18); *40232* (40); *41099* (3a); *42743* (18); *44831* (6); *48388* (1).
Cottam *3674, 3754, 4458* (35); *5644* (36).
Coville *121* (2); *186* (20); *850* (30).
Coville & Funston *101* (2); *628* (37); *2071* (35).
Coville & Gilman *111* (37).
Cowles *43* (33b); *428a, 455* (15); *579* (30).
Cox *290* (33a).
Crandall *1054* (31).
Cronquist *4955* (3c); *5641* (15).
Culbertson *4790* (20).
Curtiss, A. H. *3796* (32); *6714* (3b).
Cutler *1007* (40); *2580* (32); *3220* (3a).

Dandy *510* (23).
Daniels *151* (31).
Darker *3579* (15); *5861* (35).
Darrow *2847* (35); *3631* (16b).
Darrow & Phillips *2771, 2781* (31).

Davis, R. J. *941* (15).
Deam *21584* (32); *58692, 63923, 64053* (3c).
Degener & Peiler *16114* (33b); *16982* (36).
Dekindt *543* (24).
Demaree *3251B* (32).
Diehl *2517, 2565* (39).
Dieterlen *117* (24).
Dixon *303* (16b); *335* (35).
Dodge, C. K. *335* (32).
Dombey *14* (39).
Doty *1222* (15); *1868* (30).
Drake *3053* (22).
Drouet & Cohen *4959* (33a-b); *4964* (16b).
Drouet, F. & R. *4051* (2).
Drouet & Richards *3311* (16b); *3337* (5); *3780* (1).
Drouet, et al. *3358, 3359, 3633, 3635, 3669, 3687* (1); *4097* (16b).
Drushel *11128* (32).
Drummond *352* (3a).
Dudley *1495* (35).
Duncan *7867* (3c); *8683* (3a-b); *10467* (7); *11190* (32).
Duncan & Smith *9339* (7).
Duncan, et al. *9084* (7).
Dusén *14* (8).
Duthie *3727* (22).

Eames, A. J. *9081* (32).
Eastwood *6391* (2); *12185* (30); *12391* (2); *13297* (15); *15495* (33b); *17775, 17775a* (1).
Eastwood & Howell *1159* (36); *3324* (33a); *8808* (2).
Edwards *419* (18).
Egeling *2619* (28).
Eggleston *2199, 2905* (32); *10609* (15); *17487* (39).
Ehlers *1274* (32).
Epling *7033, 7284, 10418* (33a).
Evers *32650, 32668* (32).
Ewan *2751* (35); *4240* (2); *11293* (33b); *11665, 11730, 11827* (33a); *12047* (33a-b); *12659* (33b); *12699* (33a-b-c); *13341, 13569* (33a); *13267* (33b); *14048* (33a); *14370* (5); *14950, 15302* (33b); *15471a* (33a-b); *18377, 18395* (33a); *18480* (33c); *18586* (33a).
Exell & Mendonça *169* (28).
Eyerdam *24798* (39); *25041* (8).

Farwell *669, 845b, 9273* (32).
Fassett *2076, 2760* (32).
Fassett & Wilson *15513* (32).
Faurie *52, 1577* (14); *8496, 9687* (34); *9895, 10543, 13151* (14).
Fellows *6923* (32).
Fendler *1024* (31); *1025* (33b).
Ferguson *233* (10a).
Fernald *12334* (32).
Fernald & Collins *303* (32).
Fernald & Jackson *11972* (32).
Fernald & Long *8416, 12336, 23098* (32).
Fernald & Pease *3062, 3063, 3064, 24818* (32).
Fernald, et al. *14068b* (32).
Ferriss, J. H. *26* (1).
Ferris, R. S. *1623* (20); *2090, 8470* (2); *8474* (11).
Ferris & Duncan *2496* (39); *3588* (31, 39); *3588a, 3589* (39); *3592* (40); *3593* (39).
Ferris & Duthie *941* (33a).
Fiebrig *3322* (39); *4907* (8).
Fischer *621, 627* (28).
Fisher *1569* (28).
Flett *931* (15, 33a); *1529, 1532* (34); *1702, 1931, 2019* (15); *3092* (33a).
Flowers *3249* (36).
Fogg *15041* (32).
Fosberg *R69* (35); *697* (2).
Foster, A. S. *839* (30).
Foster, M. B. et al. *1305* (3c).
Fox, et al. *1713* (3c).
Friend *10451* (3c).
Friesner *10208, 11235* (32).
Frye, T. C. & E. M. *2537* (17); *2983, 3149* (12).

Galathea Exped. *3188* (8).
Gale *383* (2).
Garrett *1397, 4069, 5699, 7164* (35).
Gates *15225* (32).
Gattinger *3796* (32).
Gentry *1194* (1, 39); *8004, 8255* (1).
Gerard *1943* (28).
Gibbs *4* (28).
Gibert *1323* (8).
Gillett, J. B. *4681, 4681A* (10b).
Gillett, J. M. *6022* (33b); *6046* (15).
Gilman *25* (31).
Glaziou *3306* (8).
Gleason *9401, 9418, 9613* (32).
Glover & Gilliland *480, 771* (10b).

Godfrey *GH1657* (28); *3981* (32); *4677* (3c).
Godman *6* (10b).
Godman, et al. *690* (33a).
Goldberg *19100* (28).
Gomez & Sousa *85* (28).
Goodding *2* (41); *4* (2); *5* (31); *58* (16b); *101, 102, 103* (40); *173, 178* (16b); *188* (1); *213* (31); *483* (33a); *722* (40); *2444* (1); *6141* (39); *6142* (16b).
Goodman *687* (33b); *1858* (35); *2337* (39).
Goodman & Hitchcock *1514* (35).
Gorman *675, 4594* (15).
Gossweiler *4298* (24).
Graham *7592* (16b); *8405, 8521* (35); *10004* (16b).
Grant, G. B. *1191, 2456* (2); *6400* (35); *6618* (2); *7144* (35).
Grant, G. B. & Wheeler *126, 6144* (2).
Grassl *5830, 7189* (32).
Gray., Pl. Exsicc. *611* (32); *1305* (3c).
Greenman *4612* (35); *5028* (32).
Greenman, J. M. & M. T. *4697, 4721* (35); *6182* (33a).
Greenway *2431* (24).
Griffith *2871* (22).

Haberer *1355* (32).
Hagenah *1160* (32).
Hall, C. C. *155, 173, 177, 178* (35); *184* (2).
Hall, E. *694* (30).
Hanna *472* (33a); *1210* (33b); *1425* (33a).
Hansen *878* (20); *879* (35).
Harding *218* (32).
Harper *6* (3b); *10, 16, 17* (3c); *37* (3a-b); *215, 34-3* (32); *1800* (3a-b); *1852* (3c); *1854, 1860* (3b); *1957, 1987* (3c); *3116* (3a-b); *3403* (3a, 32); *3762* (3a).
Harris, B. B. *708* (18).
Harris, C. C. & S. K. *3329* (15); *3335* (30).
Harrison *9160* (35).
Harrison & Larsen *7634* (35); *7891* (33a)
Hartman *56, 327* (1).
Harvey *988, 1173, 1265a* (18); *1454* (39); *1454a* (1); *1507* (18); *1722* (1).
Hassler *1319, 12535½* (8).
Hatch & Wilson *283, 325* (19).
Haupt *105* (19).
Hayden, A. *9129* (32).
Haynes *2648, 2649, 2711* (41); *2785, 3016* (11).
Hayward *315, 907* (33b); *1684* (32); *1790, 2328* (33b).
Heacock *235* (33a).
Heddle *1745* (32).
Heller *214* (32); *5024, 5201* (15); *5466* (20); *7167* (35); *7276* (2); *7583* (20); *7610* (2); *8173* (20); *8604* (2); *8995, 9145, 9380* (35); *10715* (20); *11054* (35); *11802* (20); *14101* (3c).
Heller, A. A. & E. G. *4002* (30).
Heller & Halbach *706* (32).
Henderson *595, 4062, 5071* (15).
Hendrix *165* (2).
Henry, J. K. *9080, 9084, 9085, 9086* (15).
Henshaw *197* (2).
Hermann *1851* (32); *4665* (33a-b-c); *4962, 4995* (35); *5063* (33a-b); *5594* (33a); *7534, 7621, 8745, 8774* (32); *10008* (3c); *10070* (3b); *10108* (7); *10128* (3c).
Herrera, F. L. *3009a* (8); *3084* (39).
Herter *76113, 78856, 94884, 99600* (8).
Hildebrandt *2363* (28).
Hill, R. T. *75* (18).
Hinckley *1011* (31); *1155* (16a); *1156* (31); *1157* (39); *1158* (31); *2147* (40); *3256* (39); *3404* (1); *3566* (40).
Hinton *3453* (9); *6978* (18); *8423* (9).
Hitchcock, A. S. *22546* (39).
Hitchcock, C. L. & Martin *4688* (33a); *4705* (15); *7367* (15, 33a).
Hitchcock, C. L. & Muhlick *8125* (33a); *8499, 9048, 9099* (15); *9252, 9813* (33a).
Hitchcock, C. L. & Stanford *6780* (40); *7248* (12).
Hodgdon *611* (32).
Hoogstraal & Chase *7235* (18); *7308* (17).
Hoover *1399* (35); *4770* (20); *4900* (2); *5085* (15); *5398* (35).
Horner *601* (15).
Hosie, et al. *4, 146* (32).
Hotchkiss *1614* (32).
House *3652, 4197, 4274, 4307* (32); *4982* (30); *4841, 4981* (15); *10279, 18128, 21482, 22671, 27974, 28004* (32).
Howe, M. A. *999* (30).
Howe, T. D. *66* (35).
Howell, J. T. *2834, 2886A* (2); *2948* (11); *3989* (37); *4557* (15); *4692* (20); *5031* (38); *7600* (15); *13521* (33a); *16761, 26066* (35);

Howell, T. *696* (30).
Hoyle *520* (23).
Humbert *2823, 3000, 3538* (25); *6557, 7089bis* (27); *11612* (26); *11778* (25); *12439, 12706, 13338, 14158* (27).
Humbert & Swingle *4791* (25); *5518* (26); *5581, 5705* (27).
Hunnewell *8365* (15); *8366* (30); *9478, 9479* (7); *9966* (32); *10262* (7); *10863* (36); *14445* (32); *15709* (33b); *15711* (33a); *16236, 18335* (32).

Iltis *1516* (32); *3929* (15); *3988* (33b); *4001a* (33c); *4399a, 4478a* (33a); *4640a* (33b).
Iltis & Clebsch *3718* (7).
Ingram *2723* (16a).
Innes & Warnock *479* (1); *606* (18).

Jackson, J. K. *1045* (23); *1116* (24).
Jaeger *276* (38); *548, 551* (2); *563, 571* (35).
Jameson *426* (8).
Jennings, O. E. & G. K. *6661, 7362, 7389* (32); *8173, 9411, 9490* (15); *14518* (32).
Jermy *342* (3a); *343* (39).
Johnston, I. M. *1044* (2); *1047* (41); *1595, 1807* (38); *1808* (2); *1815* (38); *1824, 1825, 1826, 1827, 1828* (2); *2420* (5); *2421* (5, 31); *2422* (5); *2423* (16b); *2424, 2425* (31); *3004* (11); *3005* (2); *3870* (31); *3871* (16b); *3872* (5); *3873, 3874* (33b); *3875* (33a); *3876* (33c); *3877, 3878, 3879* (33b); *3881* (33a); *3881a* (33c); *3882* (33a); *3882a, 3883* (33c); *3884* (33a); *3884a* (33c); *3885* (33a); *3886, 3887* (33c); *3887a* (33b); *3888a* (33c); *3888b, 3889* (33b); *3890* (33a); *3891, 3892, 3893, 3894, 3895, 3896, 3897, 3898* (33b); *3899* (33c); *3900* (31); *3901* (33b); *3901a* (33c); *3902* (33a); *3903* (33c); *3904* (31); *3904a* (33a); *3905* (33c); *3906, 3907, 3908* (33b); *7208* (18); *8067* (13); *8607* (18); *8683* (6); *8854, 9106* (18).
Johnston & Muller *307* (1); *651, 1192* (18).
Jones, G. N. *5539* (33c); *5610, 5772, 6287* (15); *18062* (32).
Jones, G. N. & F. F. *10644* (33b).
Jones, M. E. *485* (18); *798* (5); *1246* (35); *3023* (2); *5653bj* (16b); *5822ag, 5937* (35); *23495* (43); *26032* (1); *27018A* (1).
Jones, M. E. & Eggleston *19596* (2).
Jorgensen *4073* (8).
Julio *100* (39).
Jürgens *29, 308, 309* (8).

Kaessner *860* (24).
Kearney *480* (40); *984* (32).
Keck *4458* (35).
Kellogg *815* (32).
Kemp *39* (33b); *52* (15).
Kenoyer *25* (43); *1053* (18); *1566* (9); *1724* (1).
Kenoyer & Crum *2808* (18); *3910* (17).
Kew Exsicc. *1239* (33b).
Kiener *3435* (33b); *4227, 6479* (5); *8247, 10288* (33b); *10289* (31); *11323, 23695* (32).
Killip *1112, 2266, 31001, 36944* (32).
Kirkwood *1415* (15).
Kirkwood & Severy *1718* (15).
Knight *5296* (32).
Knobloch *36* (1); *5044, 5053* (39); *5557* (1a); *5573, 5928, 5936* (1); *5938, 5969* (39).
Knopf *335* (2).
Knowlton, F. H. *82, 103* (33a); *141* (31).
Krause, A. & A. *53* (34); *162* (33c).
Kreager *294* (15).

Lacás *512* (18).
Larsen *5998* (16b); *6088* (35).
Lawrence, W. E. *1857* (30).
Lawrence, W. H. *30* (15).
Learn *78* (32).
Leeds *76* (32); *149* (1); *375, 378, 379, 380, 381, 386, 388, 389, 392, 397, 398, 399* (3c); *837* (32); *3208* (3c).
Leendertz *935, 2568* (28).
Lehmann *KK97, BT776* (8).
Leiberg *3222* (2); *5535* (31).
LeSueur *1146* (1); *1540* (18).
LeTestu *4794* (23).
Liebmann *2062* (8).
Lindheimer *76* (3a); *77* (39).
Lindig *1523* (9).
Lindman *A213, A2319* (8).
Little *4196* (40).
Lloyd, F. E. (incorrect as C. E.) *20* (18); *504* (1, 39); *505* (1).
Lloyd & Kirkwood *20, 142* (18).
Lodewyks *420* (32).
Lorentz *442* (8).
Lossen *246* (8); *426* (39).
Ludlow, et al. *4116, 5494, 14233* (29); *17039, 18606* (22).
Lundell, A. A. *56* (1, 39); *96* (18).

Lundell, C. A. & A. A. *9037* (3a).
Lützelberg *18870* (8).
Lyon *812* (32).
Lyonnet *2562* (1).

Macbride *2651* (5); *7878* (2).
MacDaniels *728* (39).
MacDougal *389* (15).
MacLeay *114* (24).
Macoun *530, 14241* (15); *66445, 69265* (32); *70408, 79637, 86372, 86373, 86374, 86375, 86376, 86377* (15).
Macoun & Herriot *70371, 70372* (32); *70373* (33b).
Mackensen *1* (18).
Mackenzie, H. *10* (15).
Mackenzie, K. K. *20* (33a); *2997, 3691* (32).
MacMillan & Sheldon *2596* (32).
Maguire *10021* (1); *10055* (40); *18450* (16b); *19321, 19378, 19873, 21090* (35).
Maguire & Holmgren *27132* (33a); *22607, 25797, 25966, 26140* (35).
Maguire, B. & R. R. *10066* (1).
Maguire & Piranian *11371* (16b).
Maguire & Richards *13166* (35).
Maguire, et al. *3962, 3963* (35); *4359* (33a); *11745* (31); *14454, 14671, 14691, 14729* (35).
Maire, R. *1533* (4).
Malte & Watson *1229* (33b).
Mandon *84, 1531* (39).
Marcelline *2905* (31).
Marie *486* (40).
Marr *722* (15).
Mason, H. L. *3342a* (20); *11278* (35).
Massey *3229* (32).
Matuda *1846* (19); *26116* (1); *26350* (9); *26352* (43); *26353* (1).
Matuda & Gold *23572* (18).
Maxon *145, 6293, 6343* (32); *10833, 10841, 10843* (3c).
Maxon & Hay *3410* (19).
McAllister *2* (18); *2a* (39); *5* (33b).
McCabe *5655, 6028, 7108* (15).
McDougal *481* (31).
McFarlin *9374* (3c); *10269* (3b); *10271* (3c).
McIntosh *1344* (32).
McKeever *38* (2); *39* (11); *40* (2).
McKelvey *619, 1563* (1); *1859* (3a); *1999* (39); *2705, 2706* (2); *4695* (33a); *5102, 5109* (2).
McMurphy *453, 531* (15).
McVaugh *4577, 5137, 5313* (3c); *7675* (18); *7898* (16a); *8007* (16b); *10446, 11829* (17); *14660* (35).

Mearns *225* (1); *237* (16b); *540, 685* (1); *2044* (33a); *2687* (1); *2701* (40); *3162* (41); *3589* (33a); *3881, 4060* (2); *4274* (33a); *4491, 4736* (33b).
Meislahn *138* (3b).
Merrill & Wilcox *1218* (33a).
Metcalf, F. P. *1490* (32).
Metcalfe, O. B. *276, 711, 991* (31); *1172* (33a).
Metz *2122* (3a).
Meyer, F. G. *188, 256, 1062* (15); *1243* (33a); *2169* (30).
Meyer, F. G. & Rogers *3112* (9).
Meyer, T. *2227, 3687* (8).
Milburge *893* (15).
Millspaugh *4502* (2).
Mohr *12* (17).
Moldenke *882* (3c).
Moore, A. H. *199, 537, 1561* (32).
Moore, H. E. *5314* (1).
Moore, H. E. & Wood *3699* (17); *3926* (18); *4219* (1); *4613* (9).
Moore, J. A. & Steyermark *3046* (16a); *3047* (39); *3196* (16a); *3245, 3745* (33a).
Moore, J. W. *117* (32); *122* (33b); *767* (32); *1841* (33b).
Moore, J. W. & M. F. *10547* (32).
Moorhead *1* (18).
Moritz *370* (9).
Morley *650* (39).
Morris *76* (32).
Moss, C. E. *18988* (28).
Moss, E. H. *2151* (33b); *2752b* (33a).
Moxley *345, 346, 347, 421, 876* (2).
Moyer *99* (32).
Moyle *483* (32).
Mueller, C. H. *8256* (39).
Muenscher *9619, 9673* (15).
Muenscher, W. C. & M. W. *14361* (32); *14526* (39); *15402* (15).
Mulford *121* (39).
Muller, C. H. *2638* (18).
Munro *1021A, 1777, 1883* (28).
Munz *6726* (2); *7536* (35); *7612* (38); *9079* (20); *9683, 17165* (38).
Munz & Eggleston *19626* (2).
Munz & Harwood *3789* (37).
Munz & Johnston *8761* (35).
Munz & Keck *4865* (41).
Munz, et al. *4226* (37).
Murdoch *4304* (32); *4787* (33a).
Murie *1232* (30).

Napier *2054* (10b).
Nash *1449* (3c).

Nelson, A. *1345* (33a, 33b); *2448* (33b); *6368* (33a); *7811* (33a-b, 33b); *8781* (33b); *10676* (16b); *11217, 11217a* (40).
Nelson, A. & E. *6368* (33a).
Nelson, A. & R. A. *1158* (40); *1448* (1); *5765, 5766, 5782a, 5782b* (33a).
Nelson, J. C. *3876* (15).
Nielsen *3423* (32).
Nil *105* (42).
Norton *1405* (32).
Novogablenov *541* (34).
Nuttall, L. W. *553* (2).

O'Neill *7580* (3c).
Oosting *53* (32); *3640, 34422* (7).
Orcutt *1089, 1097* (18); *1098* (9); *1098a* (18); *1102* (39); *1142* (9); *1151* (18); *1151a* (9); *1183* (39); *1552, 1586, 1944* (1); *1989, 2218* (18); *2974* (1); *3084, 4268* (39); *5125* (9).
Ortega *5319* (9).
Otis *1073, 1074, 1139, 1148, 1149, 1150, 1151, 1152, 1153, 1156, 1157, 1158* (15); *1242* (20); *1399* (30).
Over *11098* (32); *11358* (33b); *13678, 13679, 13680, 15467, 15883* (32).

Palmer, E. *38* in 1908 (1, 39); *92* in 1885 (1); *306* in 1904 (42); *434* in 1875 (2); *455* in 1885 (18); *485* in 1906 (1); *554* in 1896 (1, 39); *660* in 1874 (3c).
Palmer, E. J. *1322, 2834* (32); *9540* (3a); *10146, 11389* (18); *13411* (3a); *27399, 27461* (3c); *28424, 28891* (32); *30543, 30661* (39); *30871* (16a); *31609* (32); *31951, 31952* (16a); *32800* (32); *33364* (3a); *35561, 36810* (32); *37964* (15); *38316* (3c).
Palmer, L. J. *235* (34).
Palmer, Wm. & King *186, 214* (32).
Parish, S. B. *1200* (41); *4728* (2); *5052* (35); *6110* (2); *6111* (41); *8513* (40); *9134* (11); *10764* (2, 11); *10765* (11); *19180* (15); *19190* (41).
Parish, S. B. & W. F. *671* (2).
Parks, H. B. *37921, 73920* (18).
Parks, H. E. *24274* (30).
Parks, H. E. & S. T. *24110, 24119* (30).
Parks, H. S. *2525* (15).
Parodi *14328* (8).
Parsons *16* (15).
Payson *2503* (31); *2814, 2883* (33b).
Payson, E. B. & L. B. *4037* (33a, 33a-b); *4453* (33a); *4917, 5074* (35).

Pease *115, 12950, 17967* (32); *22298* (33a); *22300* (15); *22419* (33a); *22499* (33c); *24195* (32).
Pease & Bean *23334, 23581, 26103, 26118* (32).
Pease & Ogden *25070, 25114, 25140* (32).
Peattie *899, 900* (7).
Peck *15996a* (15).
Peebles & Harrison *6984* (1).
Peebles, et al. *480* (40); *4657* (1).
Pegler *932* (28).
Pennell *16890* (18); *17198* (9); *17272* (42); *17476* (39); *17753* (9); *17947* (17); *18126* (39); *18178, 18646, 19533* (1).
Perrier *1168, 8261, 8262* (25); *8303, 8305* (26); *8311, 8312, 8313, 8324, 8346* (25); *18702* (26).
Perry & Myers *715* (32).
Peter *13394* (28).
Peterson *14* (39).
Phelps *65, 66* (32).
Phillips, E. A. *775* (1).
Phillips, W. S. *2280* (1); *2588, 2604* (40); *2848* (31); *2861* (1); *2866* (31); *2930* (40); *2959, 2981* (31).
Phillips, W. S. & T. K. *3342* (33b).
Phillips, W. S. & Pultz *2805* (1).
Phillips, W. S. & Reynolds *2900* (33a, 33a-b).
Pickett *231* (15).
Piper *3524* (15); *3802* (30); *4964* (15); *6059* (33a).
Plank *14* (32).
Polunin, O. *1478* (22).
Porsild, A. E. & R. T. *159, 322, 690, 1305* (34).
Porter *1121* (33a).
Porter & Rollins *5819* (33a).
Pringle *224* (40); *3900* (17); *10823* (43).
Pringle & Conzatti *1390* (18).
Pultz & Phillips *2711, 2720* (1); *2749* (31).
Purpus, C. A. *3156* (1, 18); *6052* (17); *8463* (9).
Purpus, J. A. *120* (9).
Pyron *109* (3c); *111* (3b); *190* (3c).
Pyron & McVaugh *603* (32); *1517* (3b); *1730* (32); *2056, 2526* (7); *3003* (32); *3048* (3b); *3051* (3a-b); *3056* (3b); *3085* (3c); *3101* (3b-c); *3107* (3b); *3114* (3b-c); *3119* (3c); *3132* (3b); *3155* (3c); *3175* (3b); *3175a* (3b, 3b-c).

Quer *1* (4).

Raup *6305, 6411, 6607, 6929, 8184* (32).
Raup & Abbe *3910* (33c); *4451, 4608* (32).
Rawlinson *284* (32).
Reed, F. *6180* (2).
Reed, F. M. *2244* (2); *2466* (35); *4070* (2).
Reeve *100* (32).
Rehmann *3924* (24); *3949* (24, 28); *4005* (24); *4333, 5576* (28).
Reko *5280* (1).
Rendle *301* (28).
Reverchon *15* (18); *1456* (39); *1632* (3a).
Richards & Drouet *363* (31).
Riddell *16, 1797* (3a).
Riedel *7* (8).
Robinson, C. B. *915* (32).
Robinson, T. R. & Maxon *15, 32* (32).
Rodgers, L. *404* (7).
Rodin *4403* (28).
Rogers, F. A. *5683* (28).
Rogers, H. T. *763* (15).
Rolland *6131* (32).
Rollins *51227* (35).
Rose, J. N. *2879* (1).
Rose, J. N. & Fitch *17973* (18); *18171* (39).
Rose, J. N. & Painter *6536* (39); *6694* (1); *6835* (8); *7499* (43).
Rose, J. N. & J. S. *11199* (1).
Rose, J. N. & Mrs. *18845, 19466, 19468* (39).
Rose, J. N. & Russell *19937* (8).
Rose, J. N. et al. *8268* (39); *9614, 12857* (1); *23039* (21).
Rose, L. S. *34495, 40016* (2); *45039* (20); *45342* (41).
Rose-Innes *41026* (18).
Rose-Innes & Warnock *783* (3a).
Rosendahl *448* (32); *864* (15); *1074* (33a); *2662* (32).
Rosendahl & Butters *4564* (32).
Rosendahl, et al. *1515* (15).
Rousseau *26929* (32).
Rudatis *857* (24).
Ruiz *98* (39).
Ruth *104, 706, 749* (32).
Rydberg *1184* (33b).
Rydberg & Bessey *3517, 3518, 3519* (33b).
Rydberg & Carlton *6310, 6566, 7183, 7555* (35).
Rydberg & Garrett *8666, 8997* (33b).
Rydberg & Vreeland *6588* (33a); *6589* (33b); *6590* (16b, 33b); *6591* (31).
St. John, H. *8668* (30).
Sandberg, et al. *54, 54a, 54b* (15).
Scamman *878, 1687, 1981, 2191* (34); *2493* (33c); *2790* (33a).
Schaffner *10* (39); *11* (1); *933* (39).
Schallert *6123* (30).
Schantz *51* (5).
Schelpe *2960* (28).
Schroeder *72* (18).
Schulz *753* (8).
Scouler *335* (30).
Sellow *670* (8).
Senn *1678* (32).
Sharp *44126* (39); *44168, 45375, 45864, 46264* (17).
Sharp, et al. *50255* (17).
Sharsmith *2076, 3127* (35); *3973* (33a).
Shaw *398, 902, 1060* (33a).
Shear *3834* (33a); *4616* (16b).
Sheldon *1493* (32); *8083* (15).
Shoop *553* (32).
Shreve *5120, 5334, 6743, 9041* (1).
Sim *6095* (23).
Slater *2, 3* (1a).
Small & Carter *1013* (3c).
Small & DeWinkeler *9733, 9768* (3c).
Small & Heller *214* (7).
Small & Matthaus *11627* (3c).
Small & Wilson *1762* (3c).
Small, et al. *3349* (3c).
Smiley *515* (35).
Smith, H. *2394* (29).
Smith, H. H. *3142a* (15).
Smith, L. B. *4679* (8).
Smith, R. J. *4* (20); *5* (35).
Sodiro *47/1* (8).
Soukup *1885, 3571* (39).
Soxman *191* (3a); *351* (1a); *449* (3a); *461* (39).
Spencer *261, 1468* (2); *1468b* (41); *1646* (11); *1697, 1907, 2124* (2).
Sperry *427* (39); *428* (16a); *T733* (39); *T738* (1); *1648* (18).
Steele & Steele *166* (32).
Steinbach *8254, 8574* (8).
Stewart *2204* (6).
Stewart & Johnston *2122* (1).
Steyermark *736, 779, 15644, 15809, 20198, 27499, 27855, 40256* (32); *47115, 50501, 51292* (19); *64653* (32).
Stanford, et al. *118* (39); *2187* (9).
Standley *4153* (33b); *4158* (5, 31); *4558* (5); *4626* (5, 31); *5199* (16b); *13630, 14688* (31); *14692* (5); *15173* (33b); *15318* (33b); *15318a* (33a); *15320, 15345* (15); *15363* (33c); *15396, 15732,*

15598, 16216, 16255, 16288, 16378 (33a); *16583* (15); *16970* (33c); *17055* (33a); *17164* (15); *17164a* (33a); *17228* (33c); *17321* (33b); *17483* (33c); *17714* (15); *17979, 18050* (33a); *18136* (33c); *18185, 18606* (33a); *40389* (18); *52533* (3c); *63102* (19); *73379, 92638* (3c).
Standley & Bolman *10830* (31); *11965* (32).
Stork & Horton *9388, 10719* (39).
Suksdorf *4* (15); *47, 225* (33b); *298* (15); *753* (20); *1364, 2085, 2644, 2645, 2646* (15); *6735, 6736, 6811* (30); *7412, 8563* (15); *8834* (33a).
Summers *2209* (30).
Svenson & Fassett *3021* (32).
Swynnerton *M17a* (28).

Tamayo *298* (8); *1753, 1773* (9).
Tarleton *188* (34).
Taylor, B. C. *1573* (32).
Taylor, L. E. *2144* (18).
Taylor, M. *419* (18).
Taylor, T. M. C. *1099, 1135, 1290* (15); *2014* (33a-b); *2015, 2023* (33a); *2085* (15); *9794* (33a); *46024* (15).
Taylor, T. M. C. & Pillsburt *46118* (15).
Taylor, T. M. C., et al. *71, 144* (32).
Tharp *1792* (9); *43-513, 43-514* (18); *44027* (3a).
Thompson, J. W. *2010, 2615* (15); *3113* (30); *4002, 4029, 4058, 4102* (15); *4115* (30); *4164* (15); *4474, 4484* (30); *4844a, 5263, 5478, 5695* (15); *5779* (33a); *5912* (15); *5932* (30); *6040* (15); *6241* (30); *6355* (15); *6615* (33a); *6797, 7458, 8128, 8747* (15); *9399* (30); *10124* (15); *10583* (33a); *11425, 12752* (30); *13565* (33a).
Thornber *315* (1, 40).
Thorne *5105* (3b); *9394* (3c).
Thurow *7, 8* (3a).
Thwaites *1414* (10a).
Tisserant *3587* (23).
Toumey *1* (16b).
Tovar *338* (39).
Townsend *17* (7).
Tracy, J. P. *9783, 16452* (15).
Tracy, S. M. *3510* (3b); *7554* (3c).
Tracy, S. M. & Earle *275* (16a-b).
Train *371* (35).
Trask *21* (2).
Trelease *420* (1); *2641* (15); *2642* (34).
Tryon, R. M. *1902, 2685, 3439, 4781, 4826* (32); *5008, 5009, 5010, 5011, 5012, 5013* (3c); *5014, 5016, 5017* (3b); *5018, 5019, 5021, 5024, 5026, 5027, 5093* (3c).
Tryon, R. M. & A. F. *5005* (32); *5015* (6); *5030* (3a); *5031, 5032* (39); *5033* (3a); *5034, 5035, 5037* (18); *5039* (39); *5043* (40); *5047* (39); *5048* (40); *5050, 5051* (1); *5052* (40); *5053, 5054, 5056* (2); *5057* (41); *5059* (38); *5060* (35); *5063, 5067, 5068* (20); *5070, 5071, 5072, 5073* (16b); *5074* (31); *5075* (16b); *5076* (31); *5077* (5); *5078* (31); *5079* (5); *5080* (39, 40); *5080¼* (40); *5080½, 5082* (39); *5083* (16b); *5084* (16a); *5088* (31).
Tryon, R. M. & P. F. *4695* (32).
Tuerckheim *8844* (19).
Turner *1612* (33b).
Tweedy *361* (33a).

Uhlig *845* (10b).
Ule *232* (8).
Ulke *F29* (33c).
Umbach *5, 117, 856* (33a); *5166* (32).
Underwood *1355* (3b, 3b-c); *1355a* (3b).
Underwood & Selby *1* (33b); *2* (5); *133* (33a-b, 33a-c).
Underwood & Seymour *2805* (32).

Van Eseltine *240, 501, 502* (32).
Van Schaack *2686½* (33c); *2712, 2786* (33a); *2917* (16b).
Van Schaack & Freytag *2934* (33b).
Vargas *3141, 11058* (39).
Venturi *1144, 1866* (8).
Victorin *8421* (32).
Victorin, et al. *4201, 56848* (32).
Visher *10, 25* (33b).
Vorhies *79* (16b).

Walker, E. H. *329, 2969* (32).
Walker, E. P. *365* (16b).
Walpole *2147* (30).
Wallich *2188-3* (10a).
Ward, L. F. *1024* (20).
Ware, R. A. *519* (35).
Ware, W. A. *520* (20).
Warnock *T25* (39); *479, 614* (1); *924* (18); *20893* (1); *21694* (6).
Waterfall *4622* (39); *4811, 5392* (16b); *6358* (39); *6426a* (3a); *6690, 6757* (39).
Watson, P. *3000* (28).
Watson, S. *469* (15); *1370* (35).

Webster *13* (15).
Weintraub *72a* (32).
Welsh *18089* (24).
Welwitsch *48, 49* (28); *169* (24).
Wetherill *563* (16b).
Wheeler, L. C. *2981, 3036, 3122* (33a); *3158, 3419* (15).
Wheeler, W. A. *672, 1058* (32).
Wherry & Adams *2739* (32).
White *3982* (1).
Whitford *47* (33b).
Wiegand & Manning *50* (3c).
Wiggins *4212* (2, 11); *4213* (11); *6495* (40); *6764* (35); *7295, 7407* (1); *8174, 8330, 8694* (40); *9937* (2); *9981* (41); *11189* (35).
Wiggins & Rollins *450* (1); *484, 561* (35).
Wight *14, 283, 3194* (10a).
Wild *1218, 1315* (28).
Wilkens *1891* (16a); *2023A* (39); *2422* (16b).
Williams, L. *1395* (33a); *14299* (19).
Williams, L. & R. *2126* (33b).
Williams, R. S. *534* (33b); *1400* (8); *2649* (39).
Williamson *1017, 2317* (32).
Wilms *1814* (28).
Wilson, E. H. *5411* (29).
Wilson, P. *37* (32).
Winter *88* (32).
Wolf, C. B. *3976, 5335* (35); *8461* (41).
Wolf, J. *997* (33a).
Wolff, S. E. *1324, 3115* (3a).
Wolley-Dod *193* (2).
Wood, C. E. *3547* (32).
Wood, C. E. & Clement *7204, 7503* (3c); *7571* (3b).
Wood, J. M. *11950* (28).
Woodson *1833* (16b); *1834* (33a).
Wooton *124* (1).
Wright, C. *828* (18); *1820* (8); *2106* = *2116*; *2115* (16b); *2116* (1).

Young *21* (39).

Zeller, S. M. & E. B. *748* (15).

INDEX TO NAMES

Accepted names are in Roman type; synonyms and rejected names are in *italic;* names of subgeneric categories are in CAPITALS.

ARENICOLAE 17, 18
CYLINDROSTACHYAE 16
CYLINDROSTACHYS 16
EREMOPHILAE 17, 76
EUSELAGINELLA 16
HOMOEOPHYLLAE 16
HOMOEOPHYLLUM 16
HOMOTROPAE 16
Lycopodium
  bryoides 40, 67
  carinatum 82
  ciliatum 77
  Dregei 57
  laxum 82
  rupestre 64
  struthioloides 81, 82
RUPESTRES 17, 58
SARTORII 17, 31
SELAGINELLA (Section) 16
SELAGINELLA (Subgenus) 16
Selaginella
  acanthonota 26
  amazonica 34
  Arechavaletae 34
  arenaria 26
arenicola 23
  ssp. acanthonota 26
  ssp. arenicola 26
  ssp. Riddellii 24
arizonica 78
Arsenei 41
Aschenbornii 77
asprella 75
Balansae 27
Bigelovii 22
Bolanderi 49
Bourgeaui 64
bryoides 40
caffrorum 53
capensis 53
carinata 50
Chrismarii 20
  var. *Karwinskyana* 20
  var. *Neeana* 20
cinerascens 40
columbiana 67
Coryi 28
deflexa 16

densa 66
 var. densa 68
 var. scopulorum 67
 var. Standleyi 71
denticulata 11
Dregei 57
 var. *Bachmanniana* 57
 var. *Hildebrandtiana* 57
 var. *Petersiana* 57
 var. *pretoriensis* 57
 var. *Rehmanniana* 57
 var. *Welwitschiana* 57
echinata 54
Engelmannii 68
eremophila 80
extensa 47
Fendleri 62
floridana 26
funiformis 26
gracillima 17
grisea 57
Hansenii 49
Haydenii 76
helvetica 11
Hintonii 37
humifusa 26
indica 52
Landii 81
lepidophylla 8
leucobryoides 74
longipila 52, 68
macrathera 41
Mildei 34
montanensis 43
montevideensis 34
mutica 44
 var. limitanea 46
 var. mutica 46
 var. *texana* 46
mutica × *rupincola* 21
× neomexicana 21
nivea 55
njamnjamensis 52
oregana 61
Parishii 80
pauciciliata 34
peruviana 77
 var. *Dombeyana* 77
Phillipsiana 40
porrecta 37
Preissiana 17
proxima 56
pumila 17
pygmaea 17
Quartiniana 53
Riddellii 24
Rosendahlii 43
rupestris 64
 f. *amazonica* 34
 f. *amurensis* 71
 f. *Bolanderi* 49
 f. *Bourgeaui* 64
 f. *brasiliensis* 34
 f. *caffrorum* 53
 f. *Dregei* 57
 f. *Engelmannii* 70
 f. *Hansenii* 49
 f. *Haydenii* 70
 f. *indica* 52
 f. *longipila* 68
 f. *manchuriensis* 71
 f. *montanensis* 43
 f. *peruviana* 77
 f. *Schmidtii* 71
 f. *sibirica* 71
 f. *Wallacei* 43
 f. *Wrightii* 48
 ssp. *Balansae* 27
 var. *acanthonota* 26
 var. *Balansae* 27
 var. *Bolanderi* 49
 var. *borealis* 81
 var. *brasiliensis* 34
 var. *brevipila* 81
 var. *columbiana* 43
 var. *densa* 70
 var. *Fendleri* 62
 var. *Hansenii* 49
 var. *incurva* 53
 f. *abyssinica* 53
  f. *angolensis* 53
  f. *capensis* 53
 var. *longipila* 81
  subvar. *glaucina* 81
  subvar. *viridis* 81
 mexicana 47
 var. *mexicana* 77
 var. *montanensis* 43
 var. *peruviana* 77
 var. *recurva* 57
  f. *Dregeana* 57
  f. *Welwitschiana* 57

var. *rupincola* 20
var. *Sartorii* 37
var. *shakotanensis* 43
var. *Sherwoodii* 29
var. *tortipila* 29
var. *tropica* 82
var. *Wallacei* 43
rupincola 20
Sartorii 36
var. *oregonensis* 36
var. *venezuelensis* 36
Schmidtii 71
var. *Krauseorum* 71
scopulorum 67
selaginoides 16
Sellowii 34
shakotanensis 43
Sheldonii 77
Sherwoodii 29
sibirica 71
spinulosa 11
Standleyi 71
Steyermarkii 49
struthioloides 82
tortipila 29
uliginosa 17
Underwoodii 62
var. *dolichotricha* 62
utahensis 74
Vardei 61
viridissima 28
Wallacei 43
f. *columbiana* 43
Watsonii 72
mutica 46
Weatherbiana 28
Wightii 39
var. Phillipsiana 40
var. *vetusta* 39
var. Wightii 39
Wrightii 48
Stachygynandrum rupestre 64
TETRAGONOSTACHYAE 17
TETRAGONOSTACHYS 17
TETRASTICHAE 17
TETRASTICHUS 17
Urostachys carinatus 82

Explanation of Plate

PLATE 1

Series Arenicolae

Fig. 1. S. *rupincola*, buds at ground level, *Tryon & Tryon 5051* (MO), × 10.

Fig. 2. S. *rupincola*, portion of aerial stem, *Wooton 124* (NY), × 10.

Fig. 3. S. *Bigelovii*, branching rhizome and basal portion of aerial stems, *Tryon & Tryon 5053* (MO), × 1.75.

Fig. 4. S. *arenicola* ssp. *arenicola*, stems with basal buds and rhizophores, *Tryon 5016* (MO), × 1.75.

Fig. 5. S. *arenicola* ssp. *acanthonota*, basal portion of stems, *Tryon 5009* (MO), × 1.75.

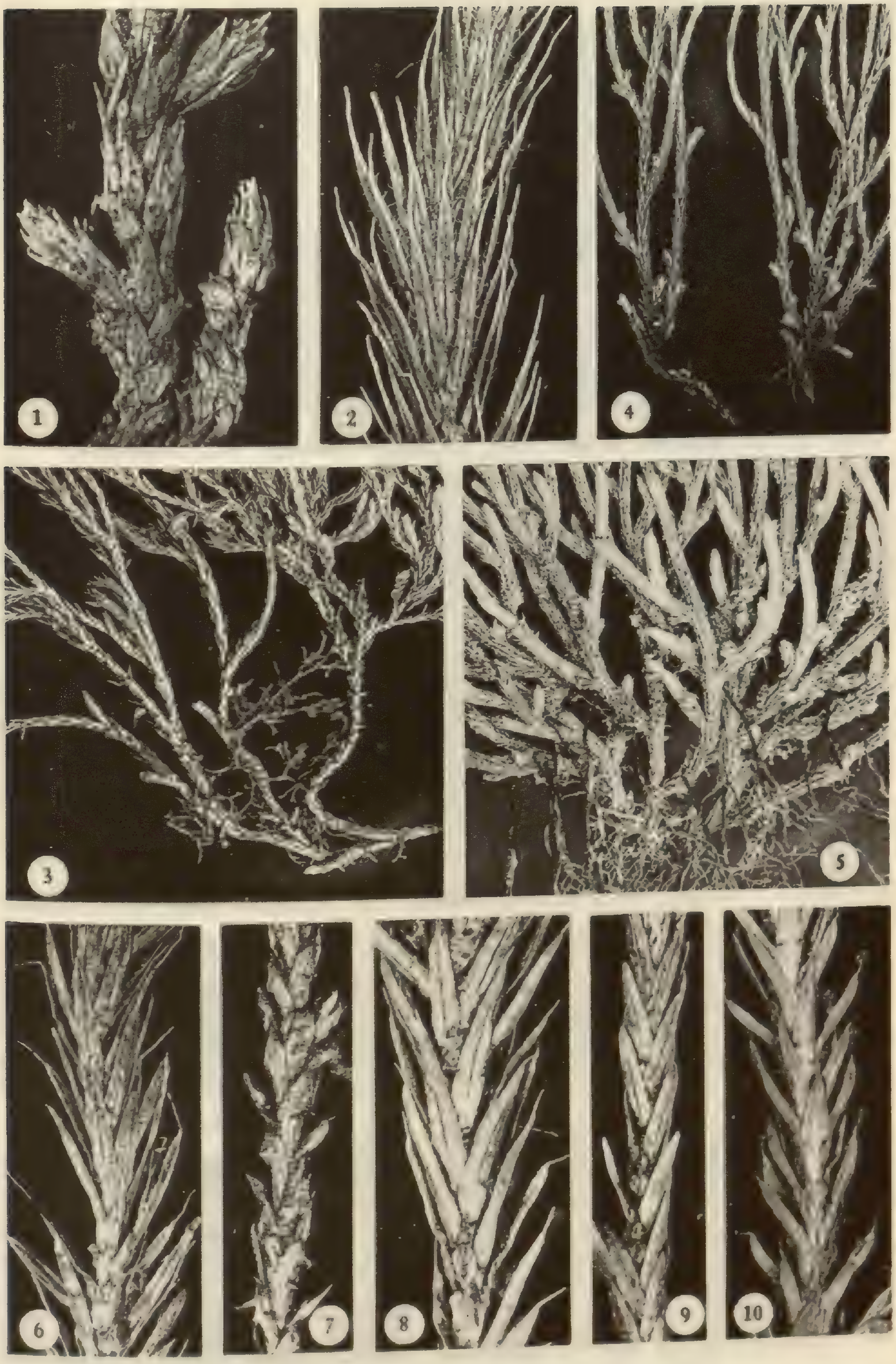
Fig. 6. S. *Balansae*, portion of aerial stem, *Balansa* (P), × 10.

Fig. 7. S. *Weatherbiana*, portion of rhizome, *Tryon & Tryon 5077* (MO), × 10.

Fig. 8. S. *Weatherbiana*, portion of aerial stem, *Standley 4558* (MO), × 10.

Fig. 9. S. *viridissima*, portion of aerial stem, Stewart *2204* (GH), × 10.

Fig. 10. S. *tortipila*, portion of aerial stem, *Rugel* (US), × 10.



TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES

TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES

Explanation of Plate

PLATE 2

Series Sartorii

Fig. 11. *S. Sellowii*, portion of stem, upper side, *Venturi 1866* (US), × 10.

Fig. 12. *S. Sartorii*, portion of stem, upper side, *Liebmann* (GH), × 10.

Fig. 13. *S. Wightii* var. *Wightii*, portion of stem, upper side, *Ferguson* (US), × 10.

Fig. 14. *S. cinerascens*, portion of stem, upper side, *Kimball* (GH), × 10.

Fig. 15. *S. Arsenei*, portion of stem, upper side, *Arsène 10641* (US), × 10.

Fig. 16. *S. macrathera*, portion of stem, upper side, *Johnston 8067* (GH), × 10.

Fig. 17. *S. shakotanensis*, strobilus, *Faurie 9895* (MO), × 10.

Fig. 18. *S. Wallacei*, portion of stem, upper side, *Wallace* (NY ex B), × 10.

Fig. 19. *S. mutica* var. *mutica*, portion of stem, upper side, *Meehan* (YU), × 10.

Fig. 20. *S. extensa*, portion of stem, upper side, *Pringle 3900* (GH), × 10.

Fig. 21. *S. Wrightii*, portion of stem, under side, *Tryon & Tryon 5034* (MO), × 10.

Fig. 22. *S. Steyermarkii*, upper leaves, *Hatch & Wilson 325* (US), × 10.

Fig. 23. *S. Steyermarkii*, under leaves, the dark areas are colored red, *Hatch & Wilson 325* (US), × 10.

Explanation of Plate

PLATE 3

Series Sartorii

Fig. 24. S. *Hansenii,* portion of stem, upper side, *Tryon & Tryon 5067* (MO), × 10.

Fig. 25. S. *carinata,* stem with branches, under side, *Rose et al. 23039* (US), × 1.25.

Fig. 26. S. *carinata,* portion of stem, upper side, *Rose et al. 23039* (US), × 1.25.

Fig. 27. S. *indica,* portion of stem, under side, *Hooker & Thomson* (P), × 10.

Fig. 28. S. *njamnjamensis,* portion of stem, under side, *Schweinfurth* (P), × 10.

Fig. 29. S. *caffrorum,* portion of stem, under side, *T. Cooper 662* (NY), × 10.

Fig. 30. S. *echinata,* upper leaves from stem apex, *Perrier 8313* (BM), × 14.

Fig. 31. S. *echinata,* under leaves from stem apex, *Perrier 8313* (BM), × 14.

Fig. 32. S. *nivea,* portion of stem, upper side, *Humbert & Swingle 5518* (US), × 10.

Fig. 33. S. *proxima,* portion of stem, upper side, *Humbert & Swingle 5705* (US), × 10.

Fig. 34. S. *proxima,* sporophylls from upper side of strobilus, *Humbert & Swingle 5705* (US), × 10.

Fig. 35. S. *proxima,* sporophylls from under side of strobilus, *Humbert & Swingle 5705* (US), × 10.

Fig. 36. S. *Dregei,* portion of stem, lateral view, *Rodin 4403* (MO), × 10.

TRYON—*SELAGINELLA RUPESTRIS* AND ALLIES

TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES

Explanation of Plate

PLATE 4

Series Rupestres

Fig. 37. S. *Vardei*, portion of stem, upper side, *E. H. Wilson 5411* (P), × 10.

Fig. 38. S. *oregana*, portion of stem, *Kautz* (YU), × 10.

Fig. 39. S. *Underwoodii*, portion of stem, under side, *Fendler 1024* (MO), × 10.

Fig. 40. S. *Underwoodii*, portion of mat, *Arsène 17963* (F), × 1.

Fig. 41. S. *rupestris*, portion of stem, upper side, *Leeds 76* (NY), × 10.

Fig. 42. S. *rupestris*, basal portion of strobilus and leaves, *J. K. Small* on Aug. 18–27, 1894 (NY), × 10.

Fig. 43. S. *densa* var. *scopulorum*, portion of strobilus, *Standley 15732* (US), × 10.

Fig. 44. S. *densa* var. *densa*, portion of stem, upper side, *Boivin & Gillett 8686* (MO), × 10.

Fig. 45. S. *densa* var. *densa*, portion of stem, under side, *Boivin & Gillett 8686* (MO), × 10.

Fig. 46. S. *densa* var. *Standleyi*, portion of strobilus, *Standley 17228* (US), × 10.

Explanation of Plate

PLATE 5

Series Rupestres

Fig. 47. S. *densa* var. *densa*, portion of mat; the dark area to the right is a region of dead vegetative branches, *Van Schaack & Freytag 2934* (MO), × 1.

Fig. 48. S. *sibirica*, portion of stem, upper side, *Calder & Billard 4454* (MO), × 10.

Fig. 49. S. *Watsonii*, portion of mat, *Tryon & Tryon 5060* (MO), × 1.

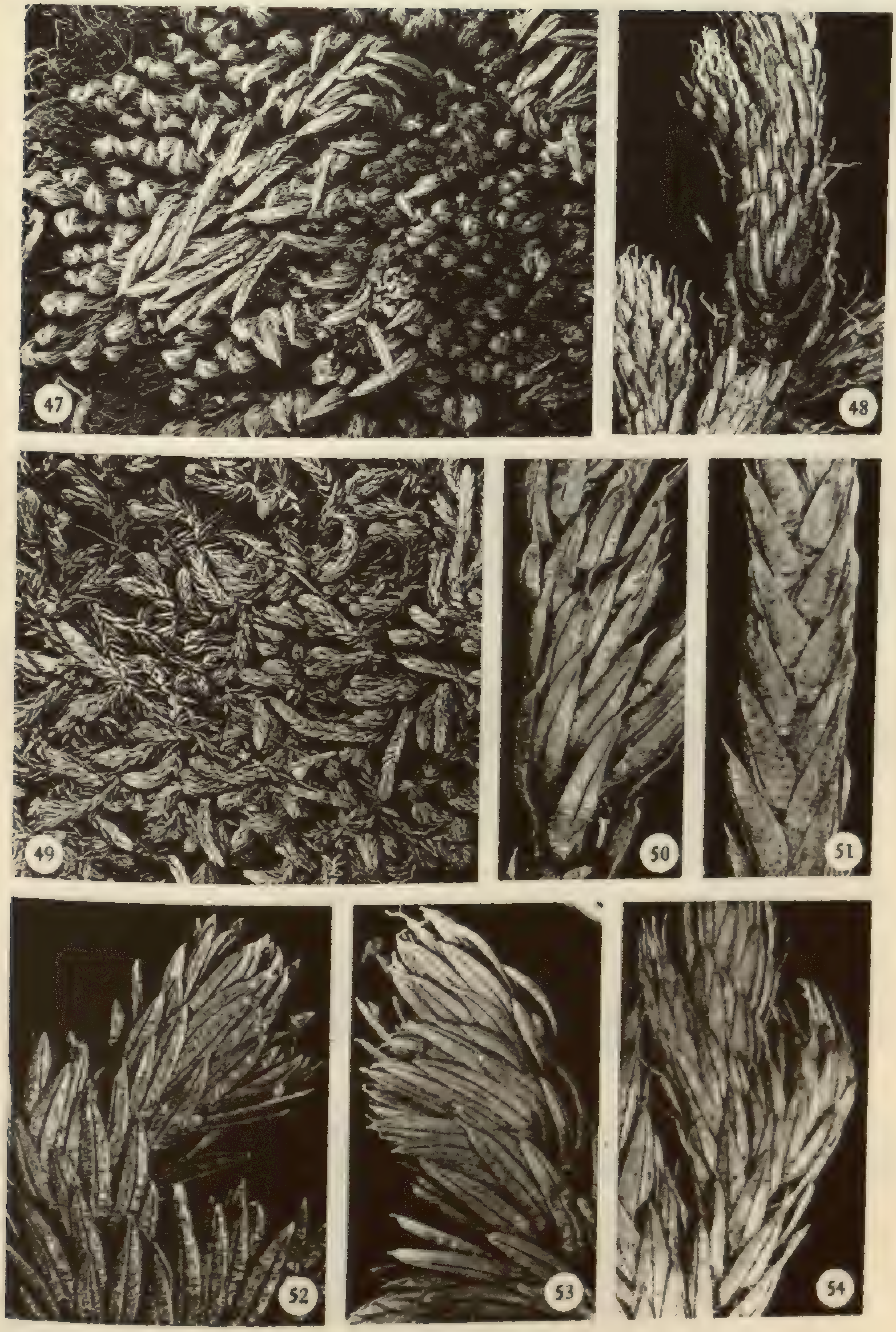
Fig. 50. S. *Watsonii*, portion of stem, upper side, *Watson 1370* (NY), × 10.

Fig. 51. S. *Watsonii*, portion of strobilus, *Watson 1370* (NY), × 10.

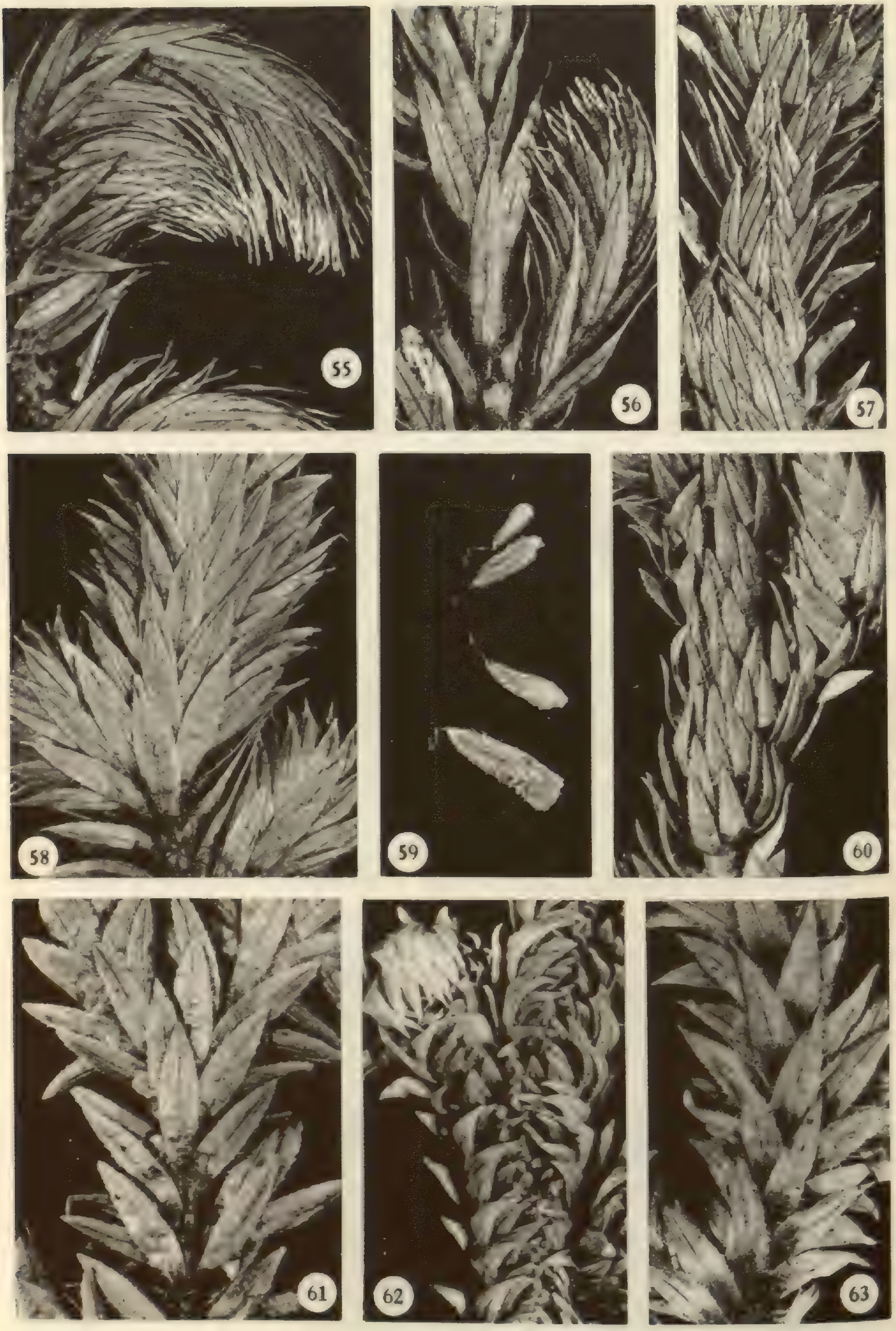
Fig. 52. S. *utahensis*, portion of stem, upper side, *Flowers 3249* (MO), × 10.

Fig. 53. S. *leucobryoides*, portion of stem, lateral view, *Munz & Harwood 3789* (NY), × 10.

Fig. 54 S. *asprella*, portion of stem, upper side, *Johnston 1815* (US), × 10.



TRYON—*SELAGINELLA RUPESTRIS* AND ALLIES



TRYON — *SELAGINELLA RUPESTRIS* AND ALLIES

Explanation of Plate

PLATE 6

Series Eremophilae

Fig. 55. S. *peruviana,* tip of stem in dormant state, *Tryon & Tryon 5031* (MO), × 10.

Fig. 56. S. *peruviana,* portion of stem, under side, *Soukup 1885* (US), × 10.

Fig. 57. S. *arizonica,* portion of stem, upper side, *W. S. Phillips 2588* (US), × 10.

Fig. 58. S. *arizonica,* portion of stem, under side, *Shreve* (US), × 10.

Fig. 59. S. *eremophila,* leaves from apical bud of stem, *Johnston 1047* (US), × 14.

Fig. 60. S. *Parishii,* portion of stem, upper side, and strobilus, *E. Palmer 306* (GH), × 10.

Fig. 61. S. *Parishii,* portion of stem, under side, *E. Palmer 306* (GH), × 10.

Fig. 62. S. *Landii,* portion of stem in dormant state, upper side, *Pringle 10823* (GH), × 10.

Fig. 63. S. *Landii,* portion of stem, under side, *Pringle 10823* (GH), × 10.

A NEW PELLAEA FROM SOUTH AFRICA*

ALICE F. TRYON

PELLAEA **rufa** sp. nov., A. F. Tryon. Rhizoma gracile repens dichotomum paleis concoloribus rufis elongato-lanceolato-triangularibus acumine filiformi basi cordata. Folia 12–30 cm. longa stipite rufo rachide rufa apicem versus flexuosa. Laminae elongato-triangulares bi-tripinnatae segmentis ellipticis vel ovatis vel nonnullis ternatis coriaceis nervis immersis. Sporangia brevissime stipitata. Sporae pallide luteolo-fuscae triplantae laeves. Typus: *Compton 16402* (US).

Rhizome slender, cord-like, dichotomously branched, long creeping. Scales of the rhizome and stipe-base concolorous, ruddy-tan, elongate lanceolate-triangular, sparsely dentate, the tip filiform, the base cordate, scales surrounding the meristem pinkish or red. Fronds 12–30 cm. long, approximate, the buds paleaceous. Stipe and rachis convex or plane on the upper surface, nearly glabrous, ruddy-tan to red becoming darker and gray with age, the upper portion of the rachis usually flexuous. Blade 10 cm. long and 2 cm. broad to 25 cm. long and 5 cm. broad, bi-tripinnate, elongate-triangular, the pinnae ascending at a broad angle to the rachis, the rachises somewhat flexuous. Segments 3 mm. long and 2 mm. broad to 10 mm. long and 6 mm. broad, elliptical or oval (some ternate), retuse, coriaceous, the veins immersed and obscure, the margin reflexed or revolute, border lutescent, crenulate, the young segments reddish. Sporangia with short stalks less than one-fourth the capsule length. Spores 64 per sporangium, tetrahedral, pale yellowish-brown, essentially smooth.

Specimens examined:

CAPE PROVINCE: Rock crevices, Ngaap Kop, Laingsburg Dist., Nov. 6, 1944, *R. H. Compton 16402* (US); Same locality, Dec. 1, 1941, *R. H. Compton 12619* (US); Foothills of Witteberg, April 19, 1925, *R. H. Compton 2961* (K); Rocky hillsides among succulents, The Great Karoo, near Matjiesfontein, Jan. 24, 1948, *Robert J. Rodin 3342* (UC, K, MO); Karoo, Groote Fontein, *Mr. Dickson*, Lady Barkly recd. 5/75 (K); Locis rupestribus montosis, siccis in dumetris, Kendo, alt. 3000–4000, 1838, *Drège* (BM, K, MO, P).

Additional localities from the Cape Province have been cited by Compton[1] from—Whitehill Ridge; Klipbank, Beaufort West Div.; and by Alston and Schlepe[2] from—Sutherland: Klein Roggeveld, Schietfontein.

This fern of the South African Karroo has had an elusive record for some hundred years. It is not surprising for the species is strange among African ferns having its closest ally, *Pellaea myrtillifolia* in the xermorphic flora of central Chile. These and two species in the southwestern United States form an alliance so close

[1]Trans. Roy. Soc. South Africa 19:270. 1931.
[2]Jour. South African Botany 18:170. 1952.

* This paper was prepared in connection with a grant from the Bache Fund of the National Academy of Sciences for the study of desert ferns.

Issued March 24, 1955.

that they were long considered as a single species. Another member of the genus, *P. ovata,* with a widespread Cordilleran range is more distantly related. Affinities of these species are easily seen in the unique, reddish color of the stipe and rachises and of the segments particularly on the immature frond. They are likewise expressed in the elongate-triangular form and generally tripinnate division of the blade, in the elliptical, retuse form of the segments and elongate, basally cordate scales. *P. andromedaefolia* of California and *P. intermedia* of southern Arizona, New Mexico, Texas and adjacent Mexico are distinguished from the Chilian and African plants in having the rhizome scales with a sclerotic central stipe. The rugose spores and compact, multicipital rhizome of *P. myrtillifolia* distinguish the Chilian plant from *P. rufa.*

The first collection, made by Drège was included by Kunze[3] under *Allosorus andromedaefolius* along with collections from California and Chile. Hooker[4] retained these under *Pellaea andromedaefolia.* The Chilian species was segregated in Kuhn's publication on the Mettenius manuscript.[5]. Later authors regarded the African record as erroneous and it was excluded until reinstated by Marloth[6], Compton and more recently by Alston and Schlepe as *P. andromedaefolia.*

The range of the species is local largely within a radius of 40 miles in the vicinity of Whitehill. Several of the collections, including the type, were made by Professor Compton whose regard for this area has resulted in an extensive flora of the Whitehill District and a Botanical Reserve for the preservation of Karroo plants. The species occurs on dry, rocky hillsides at an elevation of 3,000–4,000 feet under 5–6 inches of rainfall. It is apparently able to make rapid growth during the January rains and to tolerate long periods of desiccation. Adaptations to this environment in other genera as *Mesembryanthemum, Crassula, Helichrysum* and *Stapelia* have resulted in the striking xeromorphic flora of the Karroo.

Related species of *Pellaea* in Chile and the Southwestern United States exist under environmental conditions of essentially the same extremes. The distribution of such closely allied species in three distant regions is not a unique one. Such relationships particularly between South Africa and South America have been treated at considerable length in studies on the origin of the flora of South Africa as well as in systematic treatments of several plants and animals as the earthworms *Acanthodrilus,* the rosaceous genus *Acaena,* and *Menodora* of the *Oleaceae.* The range of the latter[7] is nearly identical to these species of *Pellaea.* Evidence from these closely related species of ferns supplies additional data on the floristic relationships of three continents.

---

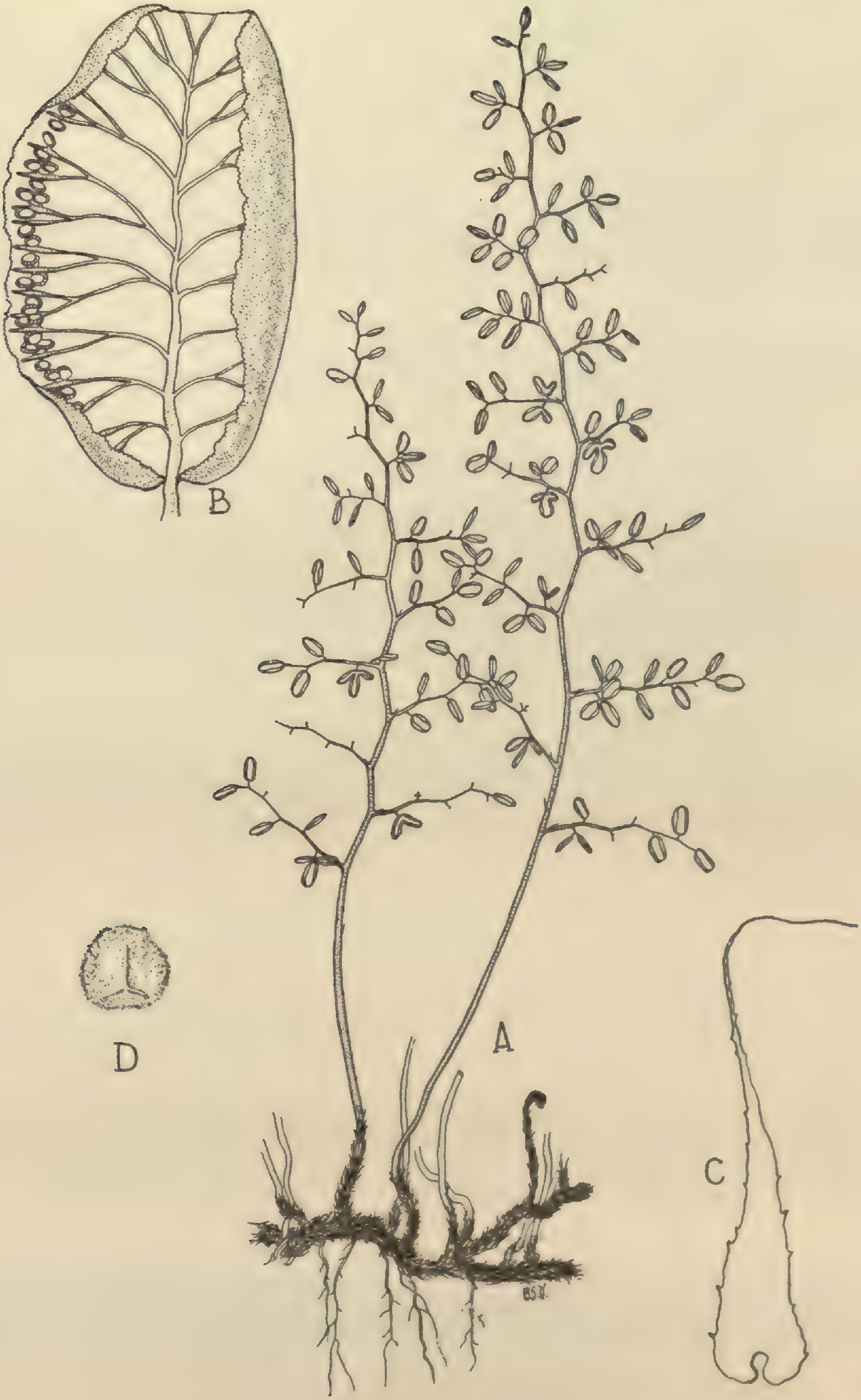
[3]Linnaea 10:503. 1836.

[4]Species Filicum 2:149. 1858.

[5]Linnaea 36:85. 1869.

[6]Das Kapland in Wiss. Ergeb. Deutschen Tiefsee-Exped. auf "Valdivia" 2^3:276. 1908.

[7]Steyermark, in Ann. Mo. Bot. Gard. 19:100. 1932.



Pellaea rufa: A, habit × ¾; B, segment with vein-ends exposed; C, rhizome scale; D, spore.

MISSOURI BOTANICAL GARDEN

STAFF

Emeritus Director
George T. Moore

Director
Edgar Anderson

Assistant Director
Hugh C. Cutler

Carroll W. Dodge, Mycologist

Robert E. Woodson, Jr., Curator of the Herbarium

Henry N. Andrews, Paleobotanist

Rolla M. Tryon, Assistant Curator of the Herbarium

Hugh C. Cutler, Curator Museum of Economic Plants

George B. Van Schaack, Honorary Curator of Grasses

Julian A. Steyermark, Honorary Research Associate

Frederick G. Meyer, Dendrologist

Alice F. Tryon, Research Associate

John D. Dwyer, Research Associate

Nell C. Horner, Librarian and Editor of Publications

Gerald Ulrici, Business Manager

BOARD OF TRUSTEES

President
John S. Lehmann

Vice-President
Daniel K. Catlin

Second Vice-President
Eugene Pettus

Leicester B. Faust
Dudley French
Henry Hitchcock
Richard J. Lockwood
A. Wessel Shapleigh
Ethan A. H. Shepley
Robert Brookings Smith

EX-OFFICIO MEMBERS

Arthur C. Lichtenberger, Bishop of the Diocese of Missouri

Stratford Lee Morton, President of the Academy of Science of St. Louis

Ethan A. H. Shepley, Chancellor of Washington University

H. M. Stolar, President of the Board of Education of St. Louis

Raymond R. Tucker, Mayor of the City of St. Louis

Gerald Ulrici, *Secretary*

Volume XLII Number 2

Annals
of the
Missouri Botanical Garden

MAY, 1955

Studies on Asiatic Relatives of Maize . . . . Nalini Nirodi 103–130

Lichenological Notes on the Flora of the Antarctic Continent and the Subantarctic Islands. I–IV . . . . Carroll W. Dodge and Emanuel D. Rudolph 131–149

Three New Annonaceae from Panama . . . . Robert E. Fries 151–152

The Botanical Catalogues of Auguste de St. Hilaire . . . . John D. Dwyer 153–170

Comparison of Juniper Populations on an Ozark Glade and Old Fields . . . . Marion Trufant Hall 171–194

PUBLISHED QUARTERLY AT GALESBURG, ILLINOIS
BY THE BOARD OF TRUSTEES OF THE MISSOURI BOTANICAL GARDEN,
ST. LOUIS, MISSOURI.

Entered as second-class matter at the post office at Galesburg, Illinois,
under the Act of March 3, 1879.

Annals
of the
Missouri Botanical Garden

A Quarterly Journal containing Scientific Contributions from the Missouri Botanical Garden and the Henry Shaw School of Botany of Washington University in affiliation with the Missouri Botanical Garden.

Information

The Annals of the Missouri Botanical Garden appears four times during the calendar year: February, May, September, and November. Four numbers constitute a volume.

Subscription Price .... $10.00 per volume
Single Numbers .... 2.50 each

Contents of previous issues of the Annals of the Missouri Botanical Garden are listed in the Agricultural Index, published by the H. W. Wilson Company.

// Annals
of the
Missouri Botanical Garden

Vol. 42 MAY, 1955 No. 2

STUDIES ON ASIATIC RELATIVES OF MAIZE[1]

NALINI NIRODI[2]

Introduction

The five oriental genera of the Tripsaceae—*Coix, Trilobachne, Polytoca, Sclerachne* and *Chionachne*—are especially worthy of an investigation more detailed than has hitherto been accorded them, not only because of their close relationship to maize but in their own right. They form a series of primitive forage plants, grain crops, and weeds, concerning which very little, aside from taxonomic descriptions, has appeared in print. As thorough as the study of maize has been, it is not improbable that a better knowledge of its Old World relatives will go some way towards helping to solve the big problem it still presents, that of its origin.

Coix is a cereal so ancient that it is mentioned in Vedic literature, was cultivated by the Aryans on the hill-slopes of the Himalayas, and at the present day is an important food grain of some of the aboriginal tribes of India (Watt, 1904). Watt infers, judging by the amount of attention the plant received in early botanical writings such as those of Pliny, Rumphius, Loureiro, and Gerarde, that formerly it was more extensively cultivated. Wester (1920), however, believes that though the hard-shelled forms of *Coix* were known in Europe as far back as the time of Pliny, the soft-shelled kinds do not appear to have been known to European writers until the seventeenth century.

The Arabs are responsible for its introduction into Spain and thereby to the West in general, and also for the picturesque name by which it is commonly known in Europe, Job's Tears (Watt, 1904).

Though a small and well-defined genus it is made up of ill-defined and poorly understood taxa, largely because of the occurrence of numerous intergrading forms. Therefore, those who have worked on the genus (Watt, Vallaeys, and Mimeur) do not agree too closely about which taxa should be allotted specific rank. In Table I are listed in chronological order as many basonyms in the genus *Coix*, as

[1] An investigation carried out in the Henry Shaw School of Botany of Washington University and submitted as a thesis in partial fulfillment of the requirements for the degree of Doctor of Philosophy.
[2] Holder of a Special Fellowship, the Pioneer Hi-Bred Corn Co., Johnston, Iowa.

TABLE I

NOMENCLATURE IN THE GENUS *COIX*

	Watt	Vallaeys	Mimeur
1. *C. Lacryma Jobi* L. Sp. Pl. 972. 1753.	1	....	1
2. *C. Lacryma Jobi* Thunb. Fl. Jap. 37. 1787.	1	....	....
3. *C. arundinacea* Lam. Encyc. Méthod. 3:422. 1789.	1	....	....
4. *C. agrestis* Lour. Fl. Cochin. 2:551. 1790.	7?	....	....
4a. *C. Lacryma-Jobi* 1. *agrestis* (Lour.) Backer, Handb. Fl. Java 2:33. 1928.	....	4b	....
4b. *C. Lacryma-Jobi* forma *agrestis* (Lour.) [incorrectly attributed to Backer by] Vallaeys in Bull. Agr. Congo Belge 39:255. 1948.	....	4b	....
5. *C. pendula* Salisb. Prod. 28. 1796.	1	....	....
6. *C. exaltata* Jacq. Eclog. Gram. 60. 1813–1820.	1	....	....
7. *C. gigantea* Koen. ex Roxb. Hort. Beng. 66. 1814.	7	....	7
7a. *C. Lachryma-Jobi* var. *gigantea* (Roxb.) Stapf ex Hook. Fl. Brit. Ind. 7:100. 1896.	7	....	....
8. *C. aquatica* Roxb. in Fl. Ind. 3:571. 1832.	8a	8c	8a
8a. *C. gigantea* Koen. ex Roxb. var. *aquatica* (Roxb.) Watt, Agr. Ledger 11:198. 1904.	8a	8c	8a
8b. *C. Lacryma-Jobi* 4. *aquatica* (Roxb.) Backer, Handbk. Fl. Java 2:33. 1928.	....	8c	....
8c. *C. Lacryma-Jobi* forma *aquatica* (Roxb.) [incorrectly attributed to Backer by] Vallaeys, l.c. 1948.	....	8c	....
9. *C. chinensis* Tod. in Index Sem. Hort. Bot. Pan. [Palermo], 5. 1861.	10a	10b	....
10. *C. Ma-yuen* Roman. in Bull. Soc. Nat. Acclimat. II, 7:442–444; 1881;	10a	10b	....
10a. *C. Lacryma-Jobi* var. "Ma-yuen" (Roman.) Stapf ex Hook. Fl. Brit. Ind. 7:100. 1896.	10a	10b	10a
10b. *C. Lacryma-Jobi* forma "Ma-yuen" (Roman.) [incorrectly attributed to Stapf by] Vallaeys, l.c. 254.	....	10b	....
11. *C. Lachryma* var. *stenocarpa* Oliver in Hook. Ic. Pl. III, 8: pl. 1764. 1888.	11	....	11
11a. *C. stenocarpa* (Oliver) Balansa in Jour. de Bot. [Paris] 4:77. 1890.	11	11b	....
11b. *C. Lacryma-Jobi* forma *stenocarpa* (Oliver) [incorrectly attributed to Stapf by] Vallaeys, l. c. 255.	....	11b	....
12. *C. puellarum* Balansa, l. c.	15	....	....
13. *C.** *tubulosa* Hack. ex Warb. in Bot. Jahrb. 13:260. 1891.	11	....	....
14. *C. lingulata* Hack. in Oest. Bot. Zeitschr. 41:5. 1891.	7	....	....
15. *C. Lacryma-Jobi* var. *monilifer* Watt, l. c. 214.	15	15a	15
15a. *C. Lacryma-Jobi* forma *monilifer* (Watt) [incorrectly attributed to Watt by] Vallaeys, l. c. 254.	....	15a	....
16. *C. Lacryma-Jobi* var. *typica* Watt, l. c. 206.	16	....	16
17. *C. ouwehandii* Koord. in Bull. Jard. Bot. Buitenz. III, 1:191. 1918.	....	....	17
18. *C. palustris* Koord. l. c.	....	18b	....
18a. *C. Lacryma-Jobi* 3. *palustris* (Koord.) Backer, l. c.	....	18b	....
18b. *C. Lacryma-Jobi* forma *palustris* (Koord.) [incorrectly attributed to Backer by] Vallaeys, l. c. 255.	....	18b	....
19. *C. poilanei* Mimeur in Rev. Internat. Bot. Appl. 31:199. 1951.	....	....	19
20. *C. lacryma-jobi* var. *major* Mimeur, l. c. 202.	....	....	20
21. *C. lacryma-jobi* var. *minor* Mimeur, l. c. 204.	....	....	21

*Here spelled *Coyx*.

delimited here, as were found. These bear the unmodified numbers 1 to 21. The list includes also a selection from the many combinations which have been made in this genus. These follow their respective basonyms and bear the same number modified by a letter. A number occurring in a column under one of the names,

Watt, Vallaeys, or Mimeur, indicates that the corresponding author equates the opposite name to that bearing the number given.

The best-known and most widely spread species is *Coix Lacryma Jobi* L. Originally native to southern and eastern Asia, it has today virtually run wild throughout the tropical and warm temperate regions of the world. The other species have a comparatively narrow distribution. *C. gigantea* Koen. ex Roxb. is found chiefly in the eastern and central parts of India, in Ceylon, Burma, and in Japan. Its variety *aquatica* has been reported in Indochina, western and southern India, Burma, and Japan. *C. ouwehandii* Koord. is endemic to Sumatra. Another endemic species is the one set up by Mimeur, *C. poilanei*, found in Laos.

Vallaeys (1948) suggests the Malay Archipelago as the center of origin of *Coix*, taking into consideration the multiplicity of varieties present there, some of which are not found elsewhere in the wild state. Accordng to Burkill (1935), "it seems early to have become a cereal of some importance in the hills of Indochina and southern China, and it is probable that the beginnings of the cultivated races should be sought for in that part of the world."

As an article of diet, *Coix* used to be known as being most important during times of famine, helping to tide over seasons when the rice crop failed. Its nutritive importance, however, has impressed many investigators, and of recent years it has been gaining in popularity as a cereal and has come to be more generally cultivated. Wester was responsible for popularizing it in the Philippines where it is known as *Adlay*. Since then similar campaigns have been set in motion in Java, Ceylon, the Belgian Congo, Guatemala, Nicaragua, Costa-Rica, Bolivia, Peru, Chile and Brazil.

Analyzed along with certain other famine foods, its energy value was found to be the highest of all those studied (Paton and Dunlop, quoted by Watt, 1904). Wester (1920) records the results of analysis of the *Bukidnon* form of *adlay* as closely approximating wheat in starch and protein content and exceeding it in fat. Comparing it with two other great cereals of the world, he says, "with a greater protein and fat content than either rice and corn it is a more complete human food than either of these cereals."

An idea of its productiveness is obtained from Pieris' statement (1936) that a crop of *adlay* from an acre of land will provide sufficient food for a family of four people for about one year. Duthie (1888), speaking of its value as a fodder, says it is largely eaten by cattle and reported to be very fattening.

Vallaeys (1948) writes of its curious use as "the object of practices and beliefs held in magic" and also of the preparation of a refreshing drink from the grain which acts as a diuretic and a depuratory. In hospitals in China it is said to form a good and cheap substitute for barley in the making of gruel. It is known to be used in the elimination of stones from the bladder (Burkill, 1935). A decoction of the roots is given to children as a vermifuge (Ridley, 1906).

It is best known, however, for its use for decorative purposes, in the making of bead-baskets, rosaries, and various articles of personal adornment. Seeds of the wild forms with the hard, lustrous shells are the ones thus employed, usually those

belonging to var. *stenocarpa,* which has elongated, cylindrical false fruits, and those of var. *typica,* with false fruits of the characteristic tear-drop shape.

This list of the uses of *Coix* could be appropriately closed with a quotation from Vallaeys. Wherever man has lived it is possible to discover vestiges of ancient cultures and of plants whose use is lost. Speaking of the regrettable tendency to limit the number of products useful as food, he writes, "Cette limitation, cette 'standardisation' ne peuvent être considérées comme un progrès. Voilà pourquoi dan certain pays, on regard la coïx comme une 'solution' a des problemes d'importance capitale d'ordre diététique, economique et social".

Both *Polytoca* and *Chionachne* are generic names which owe their origin to Robert Brown (Bennett, Horsfield & Brown, 1838). Many species have been described for both genera as a result of which the literature has become cluttered with synonyms. In "A contribution to the knowledge of the Indian Maydeae" (1931), Henrard made an attempt to clarify their taxonomy.

The following table is based on Henrard's and Pilger's treatments. It is constructed in the same way as Table I.

TABLE II

NOMENCLATURE IN THE GENUS *POLYTOCA*

	Henrard	Pilger
1. *Apluda digitata* L. f. Suppl. 434. 1781.	1a	1a
1a. *Polytoca digitata* (L. f.) Henr. in Meded. Rijks. Herb. Leid: 67:10. 1931.	1a	1a
2. *Coix heteroclita* Roxb. Fl. Ind. 3:572. 1832.	1a	—
3. *Polytoca bracteata* R. Br. in Bennett & Brown, Pl. Javan. Rar. 20. tab. 5. 1838.	1a	1a
4. *Cyathorhachis Wallichiana* Nees ex Steud. Syn. Pl. Gram. 1:403. 1854.	4a	4a
4a. *Polytoca Wallichiana* (Nees) Benth. in Jour. Linn. Soc. 19:52. 1881.	4a	4a
5. *Sclerachne cyathopoda* Muell. Fragm. Phytog. Austr. 8:116. 1873.	5a	—
5a. *Polytoca cyathopoda* (Muell.) F. M. Bailey, Queensl. Fl. 6:1849. 1902.	5a	5a
6. *Polytoca macrophylla* Benth., l. c. 1881.	6	6
7. *Chionachne Massii* Balansa in Jour. de Bot. [Paris] 4:78. 1890.	7a	—
7a. *Polytoca Massii* (Balansa) Schenck ex Henr. l. c. 67:9. 1931.	7a	7a
8. *Polytoca javanica* Henr. in Blumea 3:241. 1939.	8	8

NOMENCLATURE IN THE GENUS *CHIONACHNE*

	Henrard	Pilger
1. *Coix arundinacea* Koenig ex Willd. Sp. Pl. 4:203. 1805.	3a	—
2. *Coix barbata* Roxb. Fl. Ind. 3:569. 1832.	3a	3a
3. *Coix Koenigii* Spreng. Syst. 1:239. 1825.	3a	3a
3a. *Chionachne Koenigii* (Spreng.) Thwaites, Enum. Pl. Zeyl. 357. 1864.	3a	3a
4. *Coix crypsoides* C. Muell. in Bot. Zeit. 19:334. 1861.	3a	—
5. *Polytoca semiteres* Benth. ex Hook. Fl. Brit. Ind. 7:101. 1896.	5a	—
5a. *Chionachne semiteres* (Benth. ex Hook.) Henr. in Meded. Rijks. Herb. Leid. 67:16. 1931.	5a	5a
6. *Chionachne biaurata* Hack. in Philipp. Jour. Sci. Suppl. 1:263. 1906.	6	6
7. *Chionachne Hubbardiana* Henr. in Blumea 3:162. 1938.	7	7

The species of both *Polytoca* and *Chionachne* range in distribution from India to Australia. *Polytoca Massii* is found in Tonkin; *P. Wallichiana* in northeastern India and Pegu; *P. digitata* ranges from India to southern China and Java; *P. cyathopoda* is confined to northern Australia and Queensland; *P. macrophylla* grows in the Malay Archipelago, New Guinea, and the Louisiade Archipelago; *P. javanica* has been reported only from Java by Henrard.

Chionachne Koenigii is distributed throughout India and in Tonkin, Ceylon, the Celibes, and Queensland; *Ch. biaurata* is endemic to the Philippines; *Ch. semiteres* is found in the Deccan and Burma; *Ch. Hubbardiana* is endemic to Queensland.

The only economic use reported for these grasses is as fodder. *Chionachne Koenigii,* which is widely spread over India, is used as a fodder when young (Duthie, 1888).

Materials

All the plants used in this study were grown from seed at the Missouri Botanical Garden, both outdoors and in the experimental greenhouse. Through the Plant Introduction Station, Beltsville, Maryland, seeds of various varieties of *Coix* were obtained from India, Ceylon, the Philippines, Central America, and the Belgian Congo, and large numbers of plants were raised. Since *Coix* forms a polyploid series with haploid chromosome numbers of 5, 10 and 20, it was decided to choose one representative of each of these numbers for cytological study, as follows:

(1) A species with a haploid chromosome number of 5, bearing small, hard, chalk-white false fruits, kindly procured for our purpose from Cuttack, India, by Dr. N. Krishnaswami, Cytogeneticist, Agricultural College, Coimbatore, India.

(2) "Blue Adlay", a variety of *Coix Lacryma Jobi* L., with a haploid chromosome number of 10, obtained from Trinidad through the courtesy of Dr. William L. Brown, Geneticist, Pioneer Hi-Bred Corn Company, Iowa.

(3) A species with a haploid chromosome number of 20, bearing greenish-brown false fruits, collected on the Western Ghats (the mountain range that extends for 800 miles along the southwest and west coast of India), also sent by Dr. N. Krishnaswami.

Specific or varietal names have not been appended to (1) and (3), because their morphological characters do not conform *exactly* to any of the descriptions of *Coix* species met with in the literature.

One species of *Chionachne*—*Ch. Koenigii* (Sprengel) Thwaites ($n = 10$), sent by Dr. N. Krishnaswami from the Millet Breeding Station, Coimbatore, India, is included in this study as is also one species of *Polytoca*—*P. macrophylla* Benth. ($n = 20$)—obtained from Trinidad by Dr. William L. Brown.

Full descriptions of the five taxa are given below, and inclusive herbarium specimens are being prepared for distribution.

No members of the genera *Sclerachne* and *Trilobachne* were available for cytological or morphological study.

The following is a key to distinguish the three genera:

I. Female spikelets enclosed in stony covering formed by modified indurated leaf sheath............*Coix*
II. Female spikelets enclosed in hardened covering chiefly formed by indurated glume I.
 a. Terminal spikes male, lateral spikes mixed or female............*Polytoca*
 b. All spikes with flowers of both sexes............*Chionachne*

(1) *Coix* from Cuttack, India.—

Root-system very much branched with extremely fine roots. *Culm* erect with numerous basal leaves. *Leaf-blades* linear, very narrow, up to 5 mm. broad, the longest leaves attaining a length of about 60 cm.; prominent white midrib; at union with sheath a well-marked suture which is narrow in the middle and fans out on either side; upper leaf surface sparsely set with hairs each arising from a colorless, crateriform gland. *Sheaths* ribbed, dotted on the outer face with glandular hairs similar to those of the blade. *Inflorescences* axillary, on triangular peduncles, as many as 8 arising from one node; *false fruit* small compared to most other varieties of *Coix,* 8 mm. long and 5 mm. in diameter, flattened on one side, often constricted towards the top, turbinate, chalk-white, hard. *Male portion* of the inflorescence up to 3.5 cm. long. *Glume I* 1 cm. long, lanceolate-ovate, slightly falcate, emarginate, the margins reflexed, the glume thereby 2-keeled, enclosing glume II, the keels winged, one of them throughout, the other only in its upper half, the wings serrate. *Glume II* about the length of glume I, acute, entire, margins infolded.

This description comes fairly close to that given by Mimeur (1951) for her species, *Coix poilanei,* endemic to Laos. The finely branched root-system, the numerous basal, narrow, linear leaves, and especially the dimensions and color of the false fruits, coincide with her description of *C. poilanei.* She says, however, that "les feuilles sont en continuité directe avec les gaines dont elles ne se distinguent pas", whereas in our plant the blades are separated from the sheaths by a distinct suture. The glands on the sheath are colorless and not brown as stated by Mimeur. Also, for the male spikelets she reports "une seule fleur par épillet," while the spikelets of our plant exhibit the 2-flowered condition. In referring to her species, she remarks that it is "très proche de *Coix aquatica*" (*C. gigantea* var. *aquatica* Watt). The chromosome number of the plant under discussion is n = 5, which is the same as that determined for var. *aquatica* by Mangelsdorf and Reeves (1939).

(2) "Blue Adlay", *Coix Lacryma Jobi* L., from Trinidad.—

This is the wild "*Coix Lacryma-Jobi* proper" of Watt to which he gave the varietal name *typica* and of which he speaks as "the normal form" referring to the false fruits.

Stem erect. *Leaf-blades* lanceolate, broad, up to 3.5 cm. in width, in length variable, up to 56 cm., auriculate, glabrous, "except for the double row of ascending teeth along each of the veinlets of the upper surface—a peculiarity that gives the texture of the leaf the appearance of being embroidered and makes it backwardly hispid" (Watt, 1904). Writing further about this character, Watt says: "all the

forms of this species are at once recognized by the texture of the leaf and its peculiar scabrosities." *Ligule* membranous; union of blade with sheath marked by a broad suture. *Sheaths* quite smooth. *False fruits* ovoid-oblong, 10–11 mm. long, 7 mm. in diameter, hard, smooth, polished, bluish-white. *Male portion* of the inflorescence up to 3.5 cm. long, spikelets in two's or three's. *Glume I* 7 mm. long, lanceolate-ovate, emarginate, strongly keeled, winged in the upper half, wings serrate. *Glume II* about the length of glume I, acute, margins infolded, entire.

Text-fig. 1. *Coix poilanei* Mimeur; fig. 2. "Blue Adlay"; fig. 3. *Coix gigantea* Koen. ex Roxb. All about ⅓ natural size.

(3) *Coix* from the Western Ghats, India.—

Stem perennial, erect. *Leaf-blades* linear-lanceolate, between 2 and 2.5 cm. broad and up to 30 cm. long; both upper and lower surfaces sprinkled with hairs each arising from a crateriform gland; margins serrate. *Sheath* also with crateri-

form glands bearing hairs, but here the glands of a dark reddish hue; union of blade with sheath marked by a broad suture. *Ligule* membranous; just above ligule, at base of leaf, a tuft of stiff hairs similar to those on the rest of the leaf. *Inflorescences* axillary, 2 or more spikes emerging from the sheath of a short leaf, the spike emerging first, being borne on a longer peduncle than that of the others; peduncles flattened on one side, glabrous; *false fruits* elongate, pyriform, 1 cm. long, 5–6 mm. in diameter, mouth oblique, pale green with brown markings, slightly flattened on one side. *Male spikes* up to 4 cm. long, drooping, spikelets mostly in 3's, the lateral ones sessile and the middle one pedicellate, each 2-flowered. *Glume I* 9 mm. long, ovate-oblong, emarginate, the margins reflexed, the glume thereby 2-keeled, enclosing glume II, the keels winged throughout, margins of the wings serrulate. *Glume II* winged, acute, margins entire.

The description above corresponds in general to that given for *C. gigantea* by Roxburgh (1832) and that by Watt (1904). The important differences are discussed below:

1. Roxburgh describes the sheaths as "smooth", and Watt as "quite glabrous and eglandular". In the specimens under discussion, however, the sheaths are sprinkled with sharp hairs arising from crateriform glands of a dark reddish color.

2. The leaves are not "narrow" and "linear" as in Watt's description but "about 1 inch broad" as in Roxburgh's. They are evidently subject to variation, for Watt speaks of ". . . . Sir J. E. Smith's sheet of *C. gigantea* . . . . which has gland-dotted broad leaves . . . ."

3. With regard to the false fruits, Watt describes them as "flattened on one side, and with 2 furrows longitudinally on the flat face . . . ." While the ones described here are flattened on one side, no furrows are present, nor are any furrows mentioned by Roxburgh or by Mimeur (1951).

The name *Coix gigantea* is retained for the entity used in this study. The uncertainty of its correct application is indicated by a question mark. The chromosome number of "2n = 40" tallies with that reported for *C. gigantea* by E. K. Janaki Ammal (Darlington & Janaki Ammal, 1945).

(4) *Polytoca macrophylla* Bentham.—

Stem robust, erect. *Leaf-blades* up to 55 cm. long, between 2.5 and 3.5 cm. broad, glabrous, lanceolate, acuminate, cordate at base; margins dentate; midrib prominent; union with sheath marked by a broad suture. *Sheath* glabrous. *Ligule* narrow, membranous. *Female spikelets* 1 cm. long, variable in glume I which may be entire or toothed at summit or have 2 lateral teeth, sometimes 1. *Male spikelets* in pairs, each pair made up of 1 pedicellate and 1 sessile spikelet. *Glume I* up to 11 mm. long, acute, asymmetrical in the pedicellate spikelet, margins infolded with a broad wing along the fold on one side, wing serrate, other side merely folded slightly, lanceolate-ovate in the sessile spikelet, margins infolded, winged along the fold symmetrically on both sides. *Glume II* laterally compressed, folded along the

Text-fig. 4. *Polytoca macrophylla* Benth. About ⅛ natural size.

middle, keeled along the fold in the pedicellate spikelet; keel winged in upper half, wings serrate, very slightly keeled in the sessile spikelet. The chromosome number agrees with Avdulov's determination (1931) of 2n = 40.

(5) *Chionachne Koenigii* (Sprengel) Thwaites.—

Stem perennial, erect, freely branching at the base. *Leaf-blades* about 40 cm. long (said to attain a length of 2 feet, Ranga Achariyar, 1921), up to 1.2 cm. broad, linear, with a prominent midrib; union with sheath well-marked by a suture. *Sheaths* with scattered tubercle-based hairs at the base, sheath margins hairy. *Ligule* membranous; nodes densely ringed with hairs. *Inflorescences* axillary, most of them clustered at the ends of very long peduncles which are flattened or slightly concave on one side; leaf, in the axil of which several peduncles arise, with a sheath about 2.5 cm. long, the blade, although shorter than normal, fairly well-developed; each spike in a cluster enclosed in its lower portion by a bladeless awned sheath, 1–1.5 cm. long; 1, sometimes 2, of the lowermost spikelets female, borne in pairs of which one spikelet is sessile and the other pedicellate, the pedicel partly fused with the rhachis; rhachis pubescent. *Female spikelets* oblong, 5.5 mm. long, en-

Fig. 5. *Chionachne Koenigii* (Spreng.) Thwaites. About ⅓ natural size.

closed in glume I which becomes shiny and hard at maturity; at the union of the edges of the glume a groove through which the rhachis passes. *Male spikelets* 2-flowered. *Glume I* up to 8 mm. long, acute, pubescent, the margins infolded, the glume winged along the fold on both sides in the sessile, but only on one side in the pedicellate, spikelet; wings serrate. *Glume II* acute, laterally compressed and folded along the middle with a pronounced keel along the upper half of the fold in the pedicellate spikelet, only slightly keeled in the sessile.

Cytology

A number of cytologists have definitely established the existence of the chromosome numbers in multiples of 10 in two of the three genera of the New World Maydeae, *Euchlaena* and *Zea*. *Tripsacum* is a well-known exception; all the species and varieties have 18 pairs of chromosomes or multiples of this number. Among the Oriental Maydeae the gametic or reduced number most often encountered is also 10; this is evident from the following table:

	Gametic Number	Somatic Number	
1. *Coix Lacryma Jobi* L.	—	20	Kuwada, 1915
2. *Polytoca macrophylla* Benth.	—	40	Avdulov, 1931
3. *C. Lachryma stenocarpa* Oliver	—	20	Reeves and Mangelsdorf, 1935
4. *Sclerachne punctata* Brown	—	20	Reeves and Mangelsdorf, 1935
5. *C. Lacryma-Jobi* var. "Ma-yuen" (Roman.) Stapf	—	20	Mangelsdorf and Reeves, 1939
6. *Polytoca barbara* Stapf [*Chionachne Koenigii* (Spreng.) Thwaites]	—	20	Mangelsdorf and Reeves, 1939
7. *C. aquatica* Roxb.	5	10	Mangelsdorf and Reeves, 1939
8. *C. gigantea* Koen. ex Roxb.	—	20,40	E. K. Janaki Ammal, 1945
9. *C. poilanei* Mimeur (?)	5	10	Nirodi, 1955

The numbers in all the above taxa except 3, 4, and 7 have been confirmed in this study. *C. aquatica* (Roxb.) and *C. poilanei* Mimeur (?) are exceptional in having the gametic number 5, which is the lowest found in the Gramineae and reported so far only for the unrelated genera *Briza* and *Anthoxanthum* and for five species from two of the sub-genera of the *Sorghastreae*.

METHODS

For cytological study entire male spikes were fixed in a solution of glacial acetic acid and absolute alcohol 1:3. Two days to a week later they were transferred to 70 per cent alcohol and stored under refrigeration. Young spikes that had barely begun to emerge from the ensheathing spathe were found to be at the right stage for meiotic studies. Temporary smears were stained either with aceto-carmine or with aceto-orcein. A few were made permanent by using the dry-ice freezing technique described by Conger and Fairchild (1953).

While pachytene smears of *Coix* were being examined to investigate the possibilities for making chromomere analyses, stray cells from somatic anther-tissue were noticed showing well-stained and well-spread diploid chromosomes. These were assumed to be tapetal cells. Proof of the assumption was obtained when young anthers fixed in a solution of 3 parts absolute alcohol to 1 of glacial acetic acid were embedded in paraffin, sectioned and stained with crystal violet.

Smears made for the observation of tapetal chromosomes were treated in a slightly different way from smears made for meiotic studies. The contents of an anther were squeezed out in a drop of stain and well stirred with an iron needle. The debris was allowed to remain. After the placing of the cover-slip the slide was heated over a spirit-lamp and pressed vigorously between blotters to release the tapetal chromosomes from the nuclear membrane and spread them evenly.

CHROMOSOME MORPHOLOGY

The tapetal cells of *Coix, Polytoca* and *Chionachne* go through the process of endomitosis. At the time the pollen mother cells are undergoing pachytene the tapetal cells have already passed from the uninucleate to the binucleate condition, and smears made at this stage show many of them in endoprophase. Speaking of endoprophase stages in tomato tapetum, Brown (1949) remarks that they are "valuable for a study of somatic chromosome morphology". The same can be said of the three genera of grasses dealt with in this paper. Observations on chromosome morphology were based almost entirely on tapetal cells from anther smears. At about the middle of endoprophase, the chromosomes reach a particularly favorable degree of contraction and stain deeply enough to be identified individually. Sectioned material shows them surrounded by a nuclear membrane but in smearing the membrane may be lost.

Coix poilanei Mimeur (?).—This species, together with *Coix gigantea* var. *aquatica* Watt, occupies the lowest position in the polyploid series formed by *Coix*. Its somatic chromosome number determined both from root-tips and tapetal cells was found to be 10. At very early endoprophase the chromosomes are very much attenuated and are up to five times as long as they are at the end of this phase. They are very loosely coiled, and though they often overlap they can easily be traced throughout their length (pl. 8, fig. 1).

A characteristic of tapetal chromosomes in *Coix* is their striking differentation into regions of different staining capacity. Extremely lightly staining areas occur which are very constant in their location at a particular stage. These stand out in good contrast to the deeply staining portions, thus making the chromosomes easy to identify. Usually, and especially when they occur at the ends of the chromosomes, these achromatic regions are visibly split, with the daughter chromatids often divergent. A point to be noted at this stage is that quite often along the achromatic regions the chromomeres are visible, and two of these may be seen side by side in each diverging half of a chromosome indicating that it is made up of four chromatids (pl. 8, fig. 3A). "Achromatic" as used here is a relative term. These regions appear pale in comparison with the remaining portions of the chromosome. The chromomeres in the achromatic regions often stain clearly enough to be distinctly visible.

The five chromosomes of the haploid set have been designated A, B, C, S and D, S standing for the satellite chromosome (pl. 8, figs. 2–6). Chromosome A has a

very long achromatic region at one end, and Chromosome B has shorter achromatic regions at both ends. Chromosome C has two achromatic regions, one in each arm midway between the end and the centromere. Chromosome S is recognized by the presence of the satellite. In its elongated state it also exhibits an achromatic region in either arm but this may disappear on contraction. Chromosome D is very like Chromosome S but devoid of the satellite and shorter.

Figures 2–6 of pl. 8 show tapetal chromosomes in varying stages of contraction. Even when quite strongly contracted they can be told apart—Chromosome A and B by the difference in number and location of the achromatic regions, Chromosome S by the satellite, Chromosomes C and D by their difference in length, Chromosome D being shorter. When the achromatic regions do not occur at the ends of the chromosomes their contraction leaves wide gaps in the body of the chromosomes. Figure 6 of pl. 8 shows a late endometaphase with most of the chromosomes divided throughout but held together at the centromeres. The diverging arms give them a characteristic cruciform appearance.

Owing to the fact that there may be two or even three places along the chromosomes that show clear spaces and look like centromeres, the true position of the spindle-attachment region was ascertained from this stage and from root-tip squashes. Root-tip chromosomes examined at anaphase were found to be bent into V's with equal or slightly unequal arms indicating that all the chromosomes had median or sub-median centromeres. Plate 10, fig. 2, shows one large tapetal nucleus containing the tetraploid number of chromosomes after the completion of one endomitosis. Since the chromosomes are in early endoprophase it is probably entering a second cycle. It was not ascertained whether a second endomitosis is completed nor what degree of ploidy a tapetal cell is capable of attaining.

When the chromosome number for *Coix aquatica* Roxb. was reported by Mangelsdorf and Reeves (1939) to be 2n = 10 they observed that "no variation in the number was found". In *C. poilanei* Mimeur (?), though the tapetal cells most often showed 10 chromosomes, occasionally cells were found where 12 and rarely 11 were present. Though the nuclear membrane is ruptured on smearing, it is possible to recognize the contents as belonging to a single nucleus. Thus the possibility that the extra chromosomes might have been displaced from a neighboring nucleus due to the pressure exerted while smearing is eliminated. Besides, when pollen mother cells were examined, occasionally 6 bivalents were found at diakinesis; fig. 1 of pl. 11 shows an MI telophase where 6 chromosomes have been distributed to either pole. Due to the way in which the anthers were collected it was not possible to say with certainty whether this variation in number was between plants or between spikelets of one plant.

Coix Lacryma Jobi L.—The tapetal cells of three kinds of this species were smeared to see if varietal differences were manifest in the chromosomes. The first was "Blue Adlay", i. e. var. *typica* from Trinidad (described above). The other two were two kinds of var. "Ma-yuen". Cultivated forms of *C. Lacryma jobi* have been placed under this varietal name. Cultivation makes itself evident by

turning the stony capsule spathe soft and brittle and striated. One of the two kinds mentioned came from the Philippines and has chalk-white, brittle, and very faintly striated capsular spathes. The shape is that of var. *typica.* The other has dark brown, brittle and strongly striated capsular spathes, somewhat elongated and with a mouth larger than usual. For convenience these shall be referred to as var. "Ma-yuen (1)" and var. "Ma-yuen (2)".

A general similarity is obvious in the chromosome sets of these three kinds of *Coix.* On the whole, the chromosomes are smaller than in the 10-chromosome species. Another difference is that achromatic regions, when they occur, are usually found only towards the ends of the chromosomes. Therefore, the pronounced gaps that are left in the body of the chromosomes after a certain degree of contraction described in the 10-chromosome species are rarely met with here.

The attempt to discern homologues among the somatic chromosome sets of var. *typica,* var. "Ma-yuen (1)" and var. "Ma-yuen (2)" was confined to those chromosomes provided with pronounced achromatic ends as they helped as markers. They have been marked by small letters of the alphabet (pl. 8, figs. 7 and 8; pl. 9, fig. 1). The nucleolus chromosomes are very similar in all three, with distal ends achromatic and split. In var. *typica* and var. "Ma-yuen (2)" both nucleolus chromosomes in a diploid set possess satellites but in var. "Ma-yuen (1)" a satellite was seen on only one of them. Its homologue is seen to be in connection with the nucleolus but no satellite was observed. As in the 10-chromosome *Coix,* the centromeres are all median or sub-median which agrees with Taylor's observations (1925) on root-tip chromosomes. This is fairly clear in the tapetal chromosomes (pl. 8, figs. 7 and 8; pl. 9, fig. 1) but much more evident in pl. 11, fig. 7, where meiotic chromosomes of var. *typica* are seen in second metaphase. The chromatids prior to separation are held together at the centromere which stands out markedly.

Coix gigantea Koen. ex Roxb. (?).—Here the chromosomes, in spite of being twice as numerous as in the varieties of *C. Lacryma Jobi,* are no smaller. In fact, two pairs approach A and B in size, the two largest chromosome pairs in the 10-chromosome *Coix. Coix poilanei?* (pl. 8, fig. 3), the varieties of *C. Lacryma Jobi* (pl. 8, figs. 7 and 8), and *C. gigantea* (?) (pl. 8, fig. 2) all show their respective tapetal chromosomes in endoprophase at more or less the same degree of contraction. By comparing these figures it can be seen that many of the chromosomes of *C. gigantea* (?) are intermediate in size between those of *C. poilanei* (?) and of the 20-chromosome Coixes.

The centromeres of *C. gigantea* chromosomes stand out more clearly than those of any of the other kinds described so far. Again, all of them are either median or sub-median. This is confirmed by fig. 1 of pl. 13, where the chromosomes are in prophase of the second meiotic division. The chromatids are held together only at the centromeres and the four diverging arms of each chromosome are seen to be approximately equal.

Due to the much larger number of chromosomes present in *C. gigantea?* it was difficult to obtain cells which showed them spread at an appreciable distance from

one another. The cell shown in fig. 2 of pl. 9 was stained in aceto-orcein and does not show the nucleolus. Diakinesis stages clearly indicate the presence of two pairs of nucleolus chromosomes. From observations of carmine-stained tapetal cells it was seen that two of the nucleolus chromosomes were similar to the ones indicated by arrows (pl. 9, fig. 2). Although only one pair of chromosomes has been indicated (by X's) in var. "Ma-yuen (2)" and in *C. gigantea?* as being probably homologous, a general similarity between the genomes of the 20- and the 40-chromosome Coixes is very much in evidence. The characteristic achromatic regions are found in practically all the chromosomes of *C. gigantea?* and, as in the varieties of *C. Lacryma Jobi,* are mostly confined to the ends. The achromatic ends are visibly split and often divergent.

Occasionally, tapetal cells were noticed which had two extra chromosomes. It was not ascertained how often this occurred in the tapetal cells but when studying the meiosis, counts were made in a hundred pollen mother cells at diakinesis. Of these only two were found with an extra bivalent and one with one bivalent missing. The variation seems to be within plants.

Polytoca macrophylla Benth.—The tapetal chromosomes of this species differ from those of *Coix* in that there is no conspicuous differentiation into chromatic and achromatic regions. They stain more or less uniformly, as can be seen in pl. 10, fig. 3, where they are in endoprophase. Two nucleolus chromosomes with satellites can be observed in the same figure. Figure 4 of this plate shows them at endometaphase, more condensed and already divided as shown by the longitudinal split apparent along each chromosome. Conspicuous constrictions indicate the position of the centromeres. Plate 10, fig. 5, shows a late endometaphase. The divided halves of each chromosome are seen to diverge and are held together only at the centromere. This is a stage corresponding to the one in *C. poilanei?* (pl. 8, fig. 6). Such cruciform configurations due to union only at the centromeres are sometimes characteristic of colchicine-treated plants undergoing c-mitoses. Levan (1938) describes it in *Allium.* Brown (1949), speaking of endomitotic cycles in the tapetum of tomato, says that in some respects they resemble mitoses upset by treatment with colchicine. No cruciform stage, however, nor any evidence of protracted union at the centromere was observed by him. It is not known whether the union at the centromere in *Polytoca macrophylla* and *Coix poilanei?* is much protracted but the cruciform configurations form a definite stage in the endomitotic cycle of the tapetum in these two instances.

In the contracted condition at endometaphase (pl. 10, fig. 4), *Polytoca* chromosomes bear a likeness to somatic chromosomes of corn treated with paradichlorobenzene. This produces effects very similar to those of colchicine, one of which is to shorten the chromosomes much beyond their normal length.

Chionachne Koenigii (Sprengel) Thwaites.—In this species of *Chionachne* the tapetal chromosomes, like those of *Polytoca macrophylla,* stain more or less uni-

formly. Plate 9, fig. 3, shows them in endoprophase. The presence of satellites on the nucleolus chromosomes is doubtful. What seemed like satellites were only observed in one cell in which the chromosomes were in early endoprophase and were thin and long. They were not observed either in root-tip chromosomes or in pollen mother cells at diakinesis. The centromeres, though not marked by conspicuous constrictions as in *Polytoca,* are easy to locate. At endometaphase, the chromosomes are very much contracted and the beginnings of a longitudinal split can be observed in some of them.

MEIOSIS

Observations were made on pachytene smears of *Coix, Polytoca* and *Chionachne.* The pachytene stage in *Coix* was found to be markedly different from that of *Polytoca* and *Chionachne* in that conspicuous knobs were observed in *Coix* that were absent in the other two genera. The part played by chromosome knobs in the determination of relationships between maize and its relatives is only too well known. Considering this feature of chromosome morphology, it could be assumed that of the three genera *Coix* is the most closely related to the New World Maydeae. Longley (1941) pointed out the similarity between the chromosomes of *Zea* and those of *Coix.* Comparing the bivalents of corn and *Coix,* he showed that the variation in size in the two sets of bivalents was very similar.

A general similarity seems even more apparent on comparing the pachytene stages of a 20-chromosome *Coix* with those of corn. A glance at fig. 7 of pl. 10, however, shows that of the six knobs observable only one is internal and the rest terminal, a condition at variance with that in corn where the majority of knobs are internal. In this respect, therefore, *Coix* seems to resemble *Euchlaena* or *Tripsacum* more than corn (knobs in *Euchlaena* are both internal and terminal and in *Tripsacum* the majority are terminal). Figure 7 shows a pachytene smear from a variety of *C. Lacryma Jobi* obtained from the Sugar Cane Breeding Station, Coimbatore, India. From a study of its gross morphology this plant is classified as var. *typica.* Yet the number of its knobs differs widely from that of var. *typica* from Trinidad ("Blue Adlay"). This variation is quite in accordance with the situation in corn. Longley (1939), writing about such variation in knob number in corn, observes that it is "frequently very pronounced when plants of varieties from different geographical regions are compared". In corn, knob-forming centres can exist but not be evident unless a knob is formed at the knob-forming point, an occurrence which depends on several factors, one of them being the amount of knob material available (Longley, 1939). Figure 6 of pl. 10 shows a single chromosome of "Blue Adlay", with an elongated, terminal knob. In appearance and position it is exactly like one of the terminal knobs of var. *typica* from Coimbatore. It may well be that the position and number of knob-forming centres are similar in the two plants but that knobs make their appearance at more centres in var. *typica* from Coimbatore than in var. *typica* from Trinidad. The knobs of

var. *typica* from Coimbatore vary in appearance from large, somewhat elongated ones to smaller, more rounded ones (pl. 10, fig. 7).

The pachytene chromosomes of *C. poilanei?* were in too tangled a state to allow proper observation. The knobs in *C. gigantea?* (pl. 12, fig. 1) are small, rounded and mostly terminal. No knobs were observed in *Polytoca macrophylla* and *Chionachne Koenigii.*

If a chromomere analysis of *Coix* chromosomes were undertaken it would seem best to start with varieties of *C. Lacryma Jobi.* The pachytene stages are easy to handle and the chromosomes spread out well enough to be examined. The chromosome number being the same as in corn, similarities with and differences from corn chromosomes would be easier to identify. Only late diplotene stages of *C. poilanei?*, "Blue Adlay" and *Polytoca macrophylla* were observed. These showed a maximum of three chiasmata per bivalent in the two Coixes and up to five in *Polytoca* (pl. 9, fig. 4; pl. 13, fig. 3). In *C. poilanei?* the chromosome pairs could be identified at this stage and have been marked in the figure with the same letters used to identify tapetal chromosomes. By late diakinesis in *C. poilanei* (?) (pl. 9, fig. 5), all except the satellite bivalent are completely terminalized and lie side by side or are connected at the ends by slender filaments. The bivalent of satellite chromosomes is still connected at the satellite end and free at the other, forming a V. All five bivalents could easily be identified even in this contracted phase and have been indicated by letters as in previous figures of *C. poilanei* (?).

In "Blue Adlay", five rings and five V's were observed to make up the ten bivalents (pl. 11, fig. 2); the achromatic ends mentioned in describing the tapetal chromosomes are still noticeable and are especially clear in the distal end of the satellite bivalent.

Diakinesis in *C. gigantea* (?) deviates somewhat from the perfectly normal formation of bivalents exhibited by *C. poilanei* (?) and "Blue Adlay". One association of 4 chromosomes was seen in some pollen mother cells and some showed two rings of 4 (pl. 12, fig. 5) but the majority had 20 bivalents. These three kinds of behavior were found in pollen mother cells from the same spikelet. Evidently, the two sets of 4 chromosomes that tend to form rings possess some incipient homology.

C. gigantea (?) presumably has two pairs of nucleolus chromosomes. Two bivalents were often seen in association with the nucleolus at diakinesis and one pollen mother cell was observed which had two distinct nucleoli each associated with a bivalent. But the prominent satellites characteristic of *Coix* were only seen to be displayed by one of the bivalents (pl. 12, fig. 6).

Both *Polytoca macrophylla* and *Chionachne Koenigii* behave normally at diakinesis, regularly forming 20 and 10 bivalents respectively (pl. 13, fig. 4; pl. 14, fig. 3). The former has satellites to its two nucleolus chromosomes but none were observed in *Chionachne.*

Formation of metaphase plates and separation at anaphase I take place in the normal fashion. There is an orderly migration to the poles; and no formation of

bridges, lagging chromosomes, nor any other irregularities were observed in any of the five plants (pl. 9, fig. 6; pl. 11, fig. 3; pl. 12, fig. 7; and pl. 14, fig. 4).

At telophase I the chromosomes are seen to have formed two compact groups. By the time they emerge from telophase I and enter prophase II, the arms of the component chromatids of each chromosome are seen to diverge from the centromere with the result that the chromosomes appear cruciform. A nucleolus has been re-formed in each group. This behavior is similar in all five taxa under discussion (pl. 12, fig. 3; pl. 11, fig. 6; pl. 13, fig. 1; pl. 14, fig. 1).

At this stage, the second meiotic prophase, a curious body was seen to occur regularly in each of the two groups of chromosomes in C. *gigantea* (?). It appeared to be composed of a few darkly staining granules embedded in a lightly staining matrix (pl. 14, fig. 1). It varied in shape, being sometimes small and rounded, sometimes larger and lens-shaped. The number of granules also varied. An attempt to investigate the nature of this body was made by halving an anther containing pollen mother cells in second prophase and staining one half with aceto-carmine and the other with aceto-orcein. With aceto-carmine both nucleolus and the body showed up clearly, while the orcein-stained preparation stained neither the nucleolus nor the matrix. The granules showed extremely faintly. It would seem from this evidence that the body was in some way connected with the nucleolus. It was not seen in contact with any of the chromosomes or with the nucleolus, and so far as was observed was not seen to be in later stages.

The remaining stages of the second meiotic division leading to tetrad formation are completed in normal fashion. In *C. gigantea?* and *Ch. Koenigii* at anaphase II separation of chromatids and migration along the spindle may not take place simultaneously in both cells (pl. 13, fig. 2; pl. 14, fig. 6).

Relationship between Chromosome Number and Gross Morphology.—

Coix Poilanei?, with 10 somatic chromosomes, is essentially a small plant and even when grown outdoors did not exceed a height of three feet. The varieties of *C. Lacryma-Jobi*, 2n = 20, of which several forms of var. "Ma-yuen" and var. *typica* from different regions were raised, showed a wide variation in size, some attaining a height of 3 feet, others growing 9 feet tall. Most of them averaged 7–8 feet.

Coix gigantea?, with the highest chromosome number (2n = 40), exhibits characteristics typical of polyploids. Roxburgh (1832) describes it as attaining a height of 8–15 feet. Our plants of *C. gigantea?* were only between 5 and 6 feet high, but the leaves were coarser than in the two other species and the plants came into flower much later.

Relationship between Chromosome Number and Geographical Distribution.—

Species of *Coix* seem to have reached an optimum in the somatic number of 20. While the 10- and 40-chromosome kinds are more or less restricted in their distribution, *C. Lacryma Jobi* and its varieties have spread over the world.

Discussion

On finding that accurate chromosome counts could be made from tapetal cells, a study of their chromosome morphology was undertaken. While tapetal chromosomes at the right stage for study were being sought it gradually became apparent that they undergo what is essentially a process of endomitosis. Endomitosis in tapetal cells was first reported by Witkus (1945) in *Spinacia*. Brown (1949) showed that tapetum endomitosis in tomato differed in some respects from the process in *Spinacia*. In both cases the process ends in the formation of polyploid nuclei but whereas in *Spinacia* the nuclear membrane remains intact throughout and the chromosomes are irregularly distributed, in tomato there is a breakdown of the nuclear membrane and the chromosomes form clumps or are arranged in plates at endometaphase.

In spite of the breakdown of the nuclear membrane, Brown retains the term "endomitosis," explaining that "lack of movement of the chromosomes on a spindle rather than persistence of a nuclear membrane would seem to be the better criterion of endomitosis."

In the present study the behavior of tapetal cells follows a somewhat similar pattern to that described in tomato. The cells are uninucleate to start with but soon become binucleate following a normal mitosis, i. e., with spindle formation but without the formation of a cell wall. The chromosomes become visible as separate entities at endoprophase and contraction commences. At endometaphase the chromosomes are very much contracted and the beginning of a longitudinal split, prior to anaphase separation, is distinctly noticeable (pl. 8, fig. 9; pl. 10, fig. 4). However, the cruciform configurations at late metaphase described in *C. poilanei?* and *Polytoca* and presumably present in the other three taxa are reported by Brown to be absent in tomato.

At endoanaphase the chromosomes form dense clumps. The fact that the chromosomes fall apart at this stage was only gathered from the small size of stray chromosomes at the periphery of the clumps.

That the completion of endomitosis results in tetraploid nuclei was concluded from the larger size of many resting nuclei and from instances like the one portrayed in pl. 10, fig. 2, where a tetraploid nucleus of *C. poilanei?* is shown with its chromosomes in endoprophase of a second endomitosis. Whether this is concluded with the formation of an octoploid nucleus is not known. Except in *C. poilanei?* no tetraploid nuclei were observed in a state in which the chromosomes could be counted. For this to be possible the chromosomes would have to emerge from the resting stage and start on a second endoprophase, and this does not seem to happen in the other four taxa, and was only rarely observed in *C. poilanei?* Presumably then, endomitotic activity stops after one division and the formation of tetraploid nuclei, i. e., two tetraploid nuclei per tapetal cell. Brown reports three endomitotic cycles as normal to tapetal cells in tomato.

Sectioned material at endoprophase showed the nuclear membrane intact and fig. 9 of pl. 8 shows an endometaphase in var. "Ma-yuen (1)" with the membrane

still intact. Whether it disappears at a later stage is not definitely known but it seems unlikely. Assuming that it does not, the endomitosis in *Coix, Polytoca* and *Chionachne* resembles *Spinacia* regarding this point. According to Brown, in tomato the membrane disappears toward late endoprophase.

From what study has been made on *Coix* chromosomes it would appear that the various species and varieties dealt with in this paper form a fairly homogeneous group, with 5 as the basic chromosome number. *C. poilanei?* would then be considered a diploid species, *C. Lacryma Jobi* and its varieties tetraploids, and *C. gigantea?* an octoploid. Morphologically, the octoploid is similar to the diploid in an outstanding characteristic, the presence of crateriform glands bearing hairs. (Watt considers this characteristic as one of the more important ones that separate what he terms "the *gigantea-aquatica* series" from the *Lacryma-Jobi* series). In its chromosomes, however, the octoploid is more like the tetraploids.

Since no crossing experiments were undertaken for this study any hypothesis regarding the possible origin of the tetraploid and octoploid should be made with the necessary caution. It could be surmised that the tetraploids arose by a crossing of two similar diploids and a doubling of the chromosome number of the hybrid. They function like true diploids forming no multivalents. In the octoploid two nucleoli have been observed, and there are two sets of nucleolus chromosomes. Multivalent configurations are found. It probably originated from the tetraploid as an autopolyploid. Since its origin, its genomes have undergone changes so that it has come to function essentially as a diploid but the occasional formation of tetravalents indicates its autopolyploid beginnings.

On the basis of its pachytene chromosomes, *Coix* as a genus seems closer to the New World Maydeae than to *Polytoca* and *Chionachne*. In staining reactions, as previously described, *Polytoca* and *Chionachne* behave differently from *Coix*. Morphologically, they are similar in having the walls of their fruit-cases formed from the hardened first glume, whereas *Coix* has hardened, modified leaf-sheaths. The probability must not be overlooked that investigation of species of *Polytoca* and *Chionachne* other than those treated here might disclose the presence of pachytene knobs. The resemblance of endometaphase chromosomes of *Polytoca* to those of artificially shortened somatic chromosomes of corn has been mentioned. On the basis of the present evidence, it would seem that *Polytoca* and *Chionachne* bear a closer affinity to each other than to either *Coix* or to the New World Maydeae.

Bibliography

Avdulov, N. P. (1931). Karyo systematische Untersuchung der Familie Graminéen. Bull. Appl. Bot., Genet. & Pl. Breed. (Leningrad), Suppl. 43:1–428.

Backer, C. A. (1927). Handboek voor de Flora van Java 2:32–33.

Bailey, F. M. (1902). Queensland Flora 6:1848.

Balansa, B. (1890). Catalogue des Graminées de l'Indo-Chine Francaise. Jour. de Bot. 4:76–84.

Bennett, J. J., T. Horsfield, and Robert Brown (1838). Plantae Javanicae Rariores. pp. 15–19. London.

Bentham, George (1878). Flora Australiensis 7:515–516.
————, (1881). Notes on Gramineae. Jour. Linn. Soc. Bot. 19:14–134.
————, and J. D. Hooker (1883). Genera Plantarum 3:1112–1115.
Berger, C. A., and E. R. Witkus (1943). A cytological study of c-mitosis in the plant *Spinacia oleracea* with comparative observations on *Allium cepa*. Bull. Torr. Bot. Club 70:457–467.
Bor, N. L. (1940). Flora of Assam 5:453–459.
Brown, Spencer W. (1949). Endomitosis in the tapetum of tomato. Amer. Jour. Bot. 36:703–716.
Burkill, I. H. (1935). A dictionary of economic products of the Malay Peninsula 1:629–631.
Conger, Alan D., and Lucile M. Fairchild (1953). A quick-freeze method for making smear slides permanent. Stain Technol. 28:281–283.
Cooper, D. C. (1933). Nuclear divisions in the tapetal cells of certain angiosperms. Amer. Jour. Bot. 20:358–364.
Darlington, C. D., and E. K. Janaki Ammal (1945). Chromosome atlas of cultivated plants. 397 pp. London.
Duthie, J. F. (1888). The fodder grasses of northern India. 90 pp. Roorkee.
Gamble, J. S. (1934). Flora of Madras 3:1705.
Hackel, E. (1891). Descriptiones Graminum novorum. Oest. Bot. Zeitschr. 41:5–9.
————, (1906). Notes on Philippine Gramineae. II. Philipp. Jour. Sci. Suppl. 1:263–269.
Henrard, J. Th. (1931). A contribution to the knowledge of the Indian Maydeae. Meded. Rijks Herb. Leiden 67:1–17.
————, (1938). On a new *Chionachne* from Queensland. Blumea 3:238–242.
————, (1938). On a new species of *Polytoca* from Java. Ibid. 238–242.
Heyne, K. (1927). Die nuttige planten van Nederlandsche Indïe 1:150–152.
Holland, T. H. (1926). Adlay—its uses and prospects. Dept. Agr. Ceylon, Yearbook 1926:60–61.
Hooker, J. D. (1896). Flora of British India 7:100.
Jacquin, J. F. von (1820). Eclogae Graminum. p. 60.
Koorders, S. H. (1918). Beschreibung einer von Dr. Ouwehand im Toba-See, in Sumatra, entdeckten neuen Art von *Coix*. Jard. Bot. Buitenzorg, Bull. III, 1:190–191.
Kuwada, Y. (1915). Ueber die Chromosomenzahl von *Zea Mays* L. Bot. Mag. Tokyo 29:83–89.
Lamarck, J. B., A. P. M. de (1789). Encyclopédie Méthodique. 3:422.
Levan, Albert (1938). The effect of colchicine on root mitoses in *Allium*. Hereditas 24:471–486.
Linnaeus, C. (1753). Species plantarum. pp. 972–973.
Linnaeus, filius (1781). Suppl. Pl. Syst., Veg., Gen. Pl., et Sp. Pl. p. 434.
Longley, A. E. (1939). Knob positions on corn chromosomes. Jour. Agr. Res. 59:475–490.
————, (1941). Chromosome morphology in maize and its relatives. Bot. Rev. 7:263–289.
Loureiro, J. de (1790). Flora Cochinchinensis 2:550–551.
Mangelsdorf, P. C., and R. G. Reeves (1939). The origin of Indian corn and its relatives. Texas Agr. Exp. Sta. Bull. 574:1–315.
Merrill, E. D. (1906). An enumeration of Philippine Gramineae with keys to genera and species. Philipp. Jour. Sci. Suppl. 1:320–321.
Mimeur, Genevieve (1951). Systématique spécifique du genre *Coix* et systématique varietale de *Coix Lacryma-Jobi*. Morphologie de cette petite céréale et étude de sa plantule. Rev. Internat. Bot. Appl. Agric. Trop. 31:197–211.
Müller, Carolus (1861). De graminibus novis vel minus cognitis. Bot. Zeit. 19:332–335.
Mueller, F. von (1875). Fragmenta Phytographiae Australiae 8:116–117.
Pieris, H. A. (1936). Adlay. Trop. Agr. (Ceylon) 86:217–219.
Pilger, R. (1940). Gramineae. III. Unterfamilie Panicoideae. Engler & Plantl's Nat. Pflanzenfam. 14^{e}:184–201.
Ranga Achariyar (1921). A handbook of some South Indian grasses. pp. 140–142.
Reeves, R. G., and P. C. Mangelsdorf (1935). Chromosome numbers in relatives of *Zea Mays* L. Amer. Nat. 69:633–635.
Ridley, H. N. (1906). Malay drugs. Agr. Bull. Straits & Fed. Malay States 5:193–206.
Roxburgh, W. (1832). Flora Indica 3:568–572.
Royen, A. Van (1740). Flora Leydensis. p. 72.
Salisbury, R. A. (1796). Prodromus stirpium in Horto ad Chapel Allerton vigentium. p. 28.
Smith, F. H. (1933). Nuclear divisions in the tapetal cells of *Galtonia candicans*. Amer. Jour. Bot. 20:341–347.
Sprengel, Curt. (1825). Systema vegetabilium 1:238–239.
Stapf, O. (1888). Job's Tears (*Coix Lachryma* L. var. *stenocarpa*). Kew Bull. Misc. Inf. 1888:144–145.
Steudel, E. G. (1854). Synopsis Plantae Graminum 1:403.
Taylor, William Randolph (1925). Chromosome constrictions as distinguishing characters in plants. Amer. Jour. Bot. 12:238–244.

Thunberg, C. P. (1784). Flora Japonica. p. 37.
Thwaites, G. H. K., and J. D. Hooker (1864). Enumeratio plantarum zeylaniae. p. 357.
Vallaeys, G. (1948). Le "Coix Lacryma-Jobi". Bull. Agric. Congo Belge 39:247–304.
Warburg, O. von (1891). Beiträge zur Kenntnis der papuanischen Flora. Bot. Jahrb. 13:230–272.
Watt, George (1889). A dictionary of the economic products of India. 2:492–500.
————, (1904). *Coix* spp. or Job's Tears. A review of all available information. Agr. Ledg. 11:189–229.
Weatherwax, P. (1926). Comparative morphology of the Oriental Maydeae. Indiana Univ. Studies 73:1–18.
Wester, P. J. (1920). Notes on Adlay. Philipp. Agric. Rev. 13:217–222.
Willdenow, C. L. (1805). Species Plantarum 4:202–203.
Witkus, E. R. (1945). Endomitotic tapetal cell divisions in *Spinacia*. Amer. Jour. Bot. 32:326–330.

Explanation of Plate

PLATE 8

Figs. 1–4. *Coix poilanei* Mimeur. Tapetal chromosomes in endoprophase.

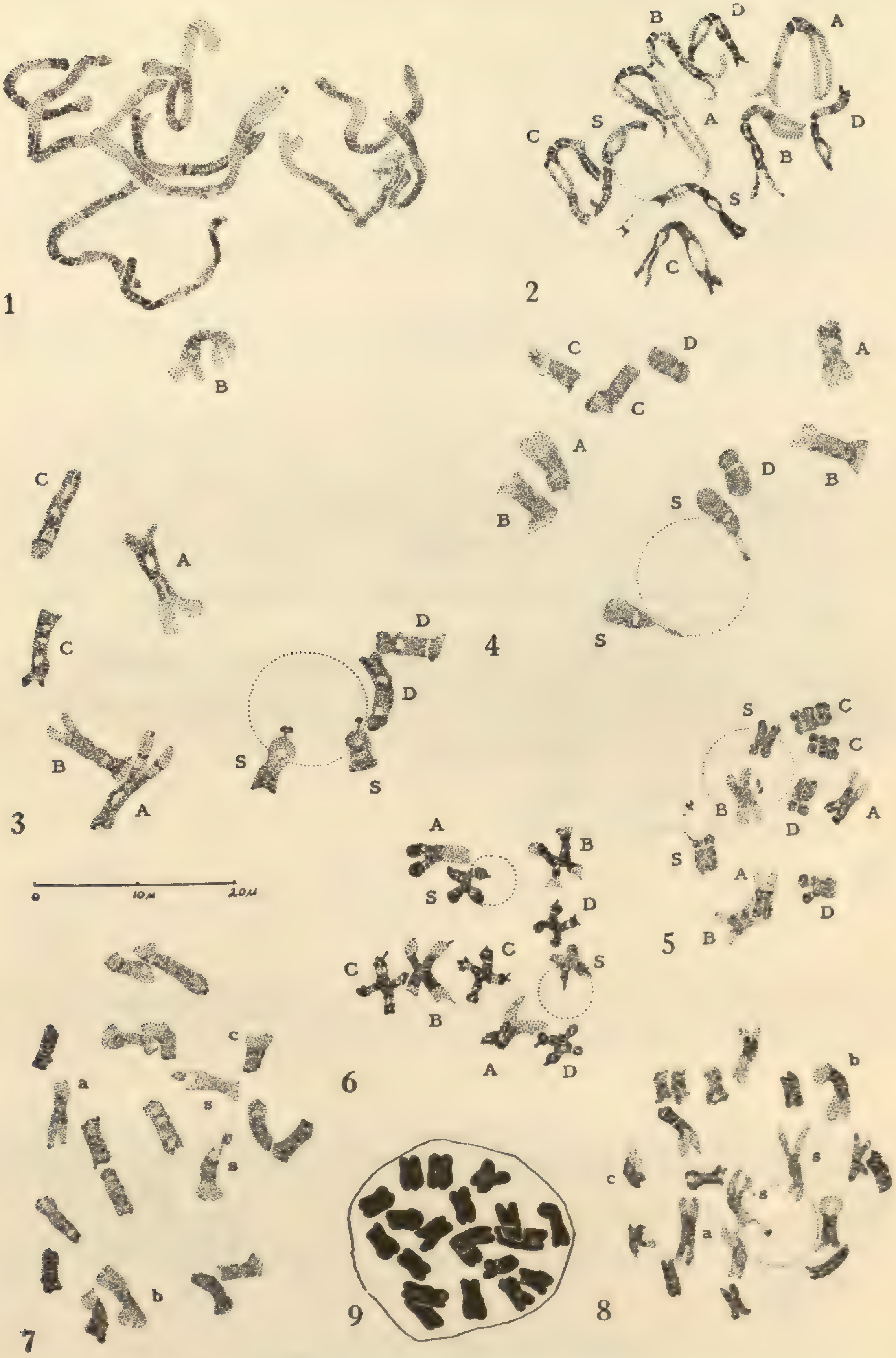
Fig. 5. *Coix poilanei.* Tapetal chromosomes in endometaphase.

Fig. 6. *Coix poilanei.* Tapetal chromosomes in late endometaphase.

Fig. 7. "Blue Adlay" (*C. Lacryma Jobi* var. *typica* Watt), from Trinidad. Tapetal chromosomes in endoprophase.

Fig. 8. Var. "Ma-yuen (1)" (*C. Lacryma Jobi* L. var. "Ma-yuen" Stapf). Tapetal chromosomes in endoprophase.

Fig 9. Var. "Mayuen (1)". Tapetal chromosomes in endometaphase.



NIRODI—ASIATIC RELATIVES OF MAIZE

Explanation of Plate

PLATE 9

Fig. 1. Var. "Ma-yuen (2)" (*C. Lacryma-Jobi* L. var. "Ma-yuen" Stapf). Tapetal chromosomes in endoprophase.

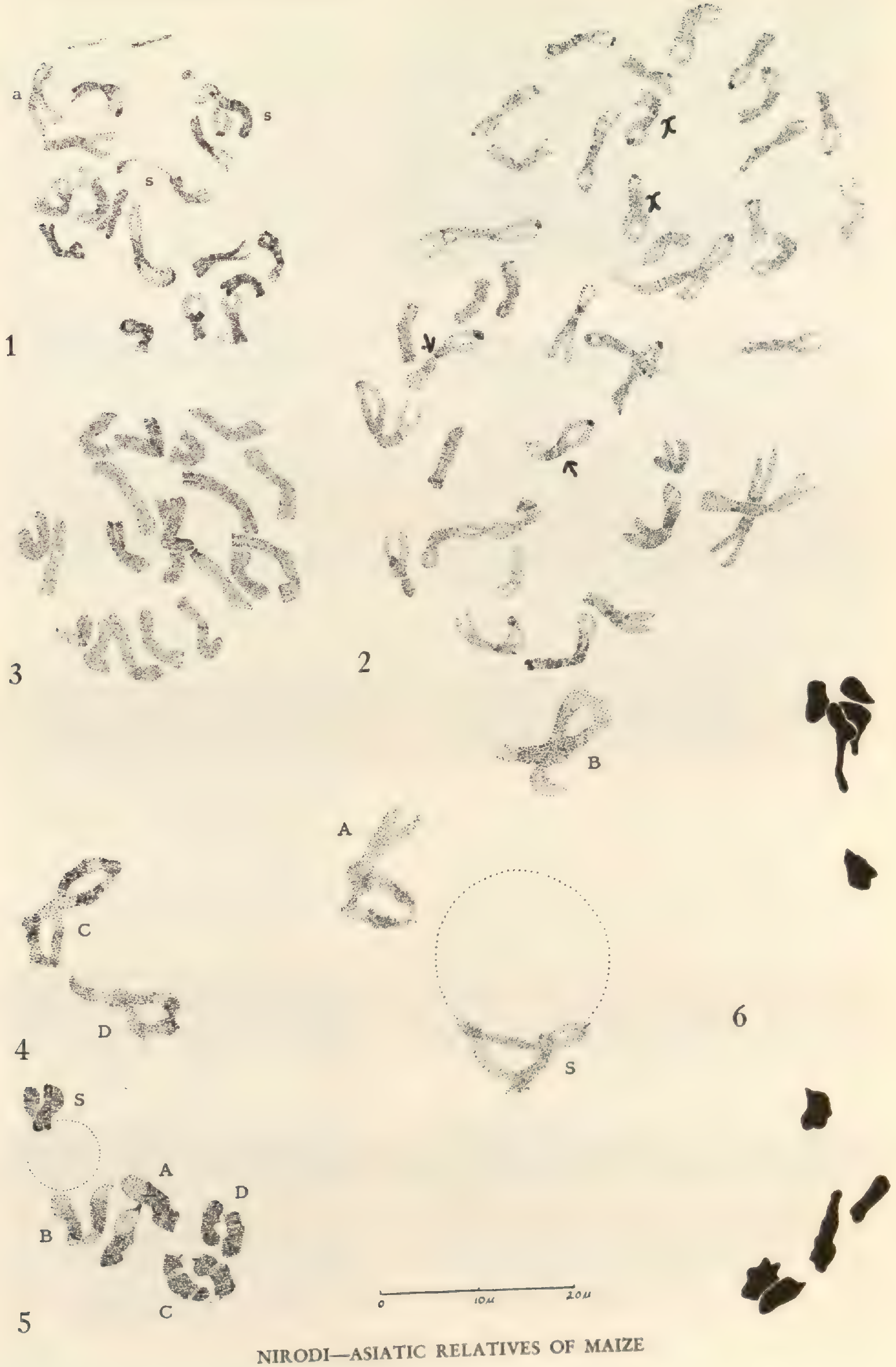
Fig. 2. *Coix gigantea* Koen. ex Roxb. Tapetal chromosomes in endoprophase.

Fig. 3. *Chionachne Koenigii* (Spreng.) Thwaites. Tapetal chromosomes in endoprophase.

Fig. 4. *Coix poilanei.* Mimeur. Diplotene.

Fig. 5. *Coix poilanei.* Diakinesis.

Fig. 6. *Coix poilanei.* Anaphase I.



NIRODI—ASIATIC RELATIVES OF MAIZE

Explanation of Plate

PLATE 10

Fig. 1. *Coix poilanei* Mimeur. Showing twelve tapetal chromosomes in endoprophase.

Fig. 2. *Coix poilanei.* Tapetal cell with tetraploid number of chromosomes undergoing a second endomitotic cycle.

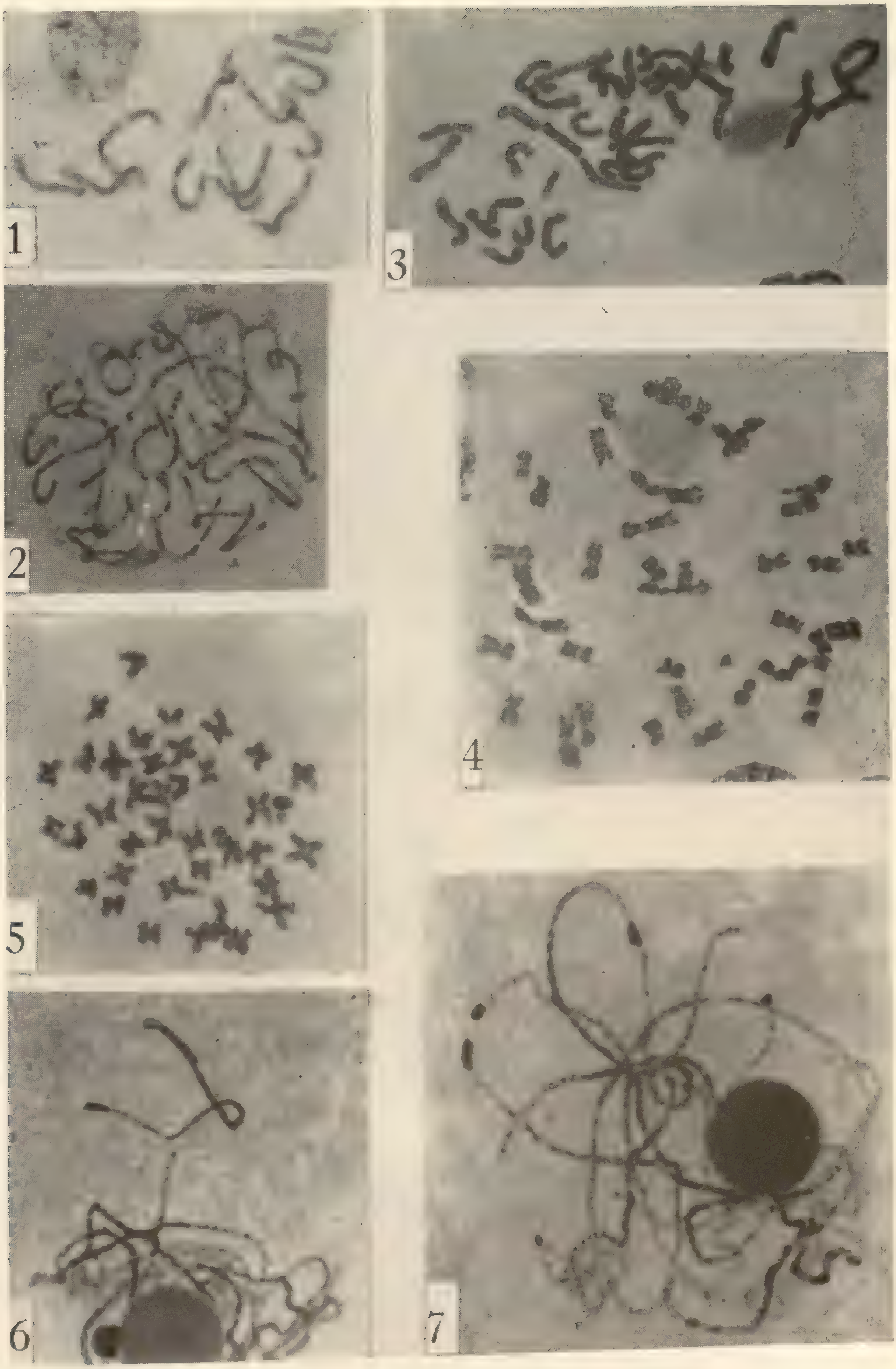
Fig. 3. *Polytoca macrophylla* Benth. Tapetal chromosomes in endoprophase. × 1350.

Fig. 4. *Polytoca macrophylla.* Tapetal chromosomes in endometaphase. × 1350.

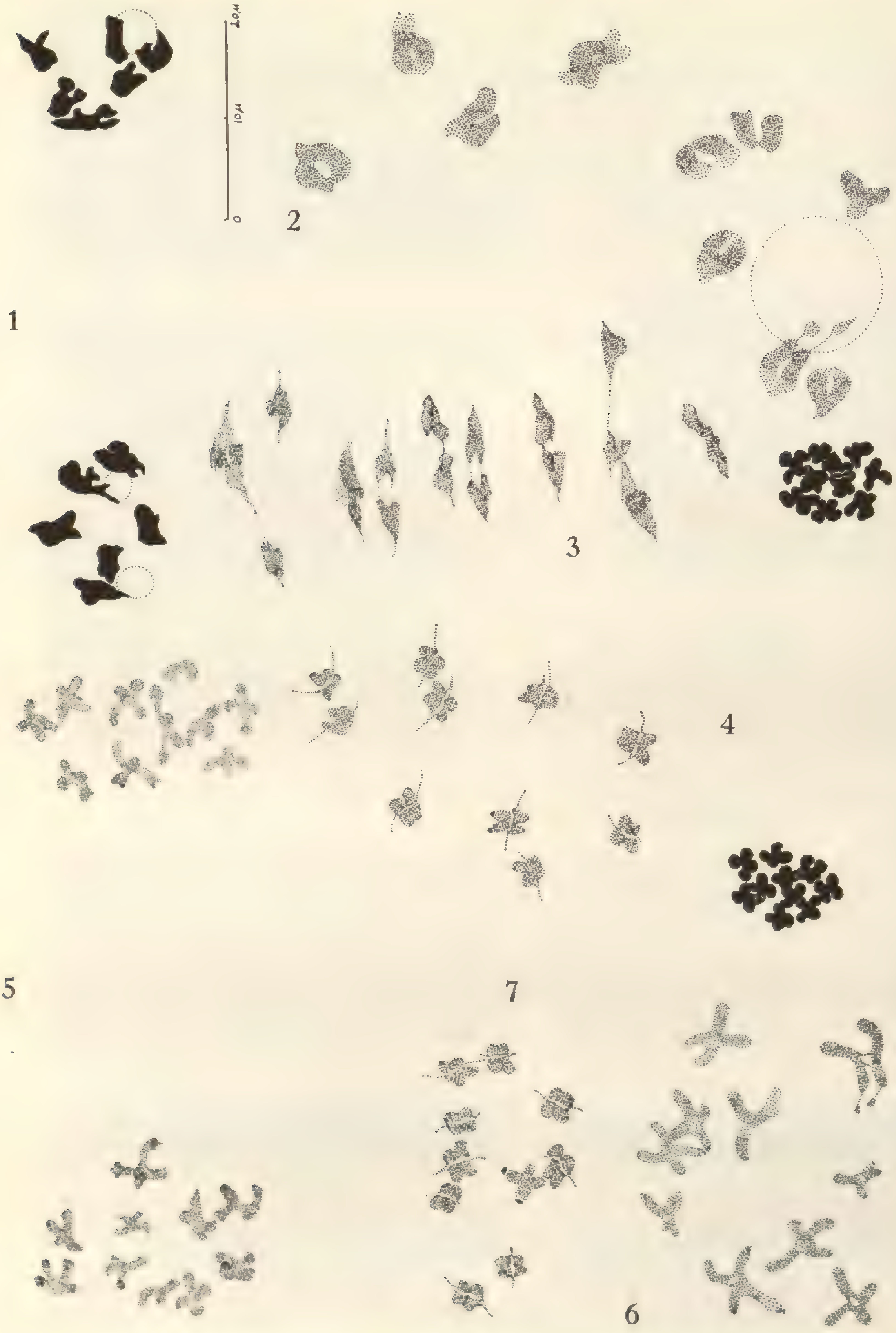
Fig. 5. *Polytoca macrophylla.* Tapetal chromosomes in late endometaphase.

Fig. 6. "Blue Adlay." Pachytene. × 1350.

Fig. 7. *Coix Lacryma Jobi* var. *typica,* from Coimbatore. Pachytene. × 1350.



NIRODI—ASIATIC RELATIVES OF MAIZE



NIRODI—ASIATIC RELATIVES OF MAIZE

Explanation of Plate

PLATE 11

Fig. 1. *Coix poilanei* Mimeur. Telophase I of a 12-chromosome cell.

Fig. 2. "Blue Adlay." Diakinesis.

Fig. 3. "Blue Adlay." Anaphase I.

Fig. 4. "Blue Adlay." Telophase I.

Fig. 5. "Blue Adlay." Late Telophase I.

Fig. 6. "Blue Adlay." Prophase II.

Fig. 7. "Blue Adlay." Metaphase II.

Explanation of Plate

PLATE 12

Fig. 1. *Coix gigantea* Koen. ex Roxb. Pachytene. × 1350.

Fig. 2. *Coix poilanei* Mimeur. Telophase I of normal 10-chromosome cell.

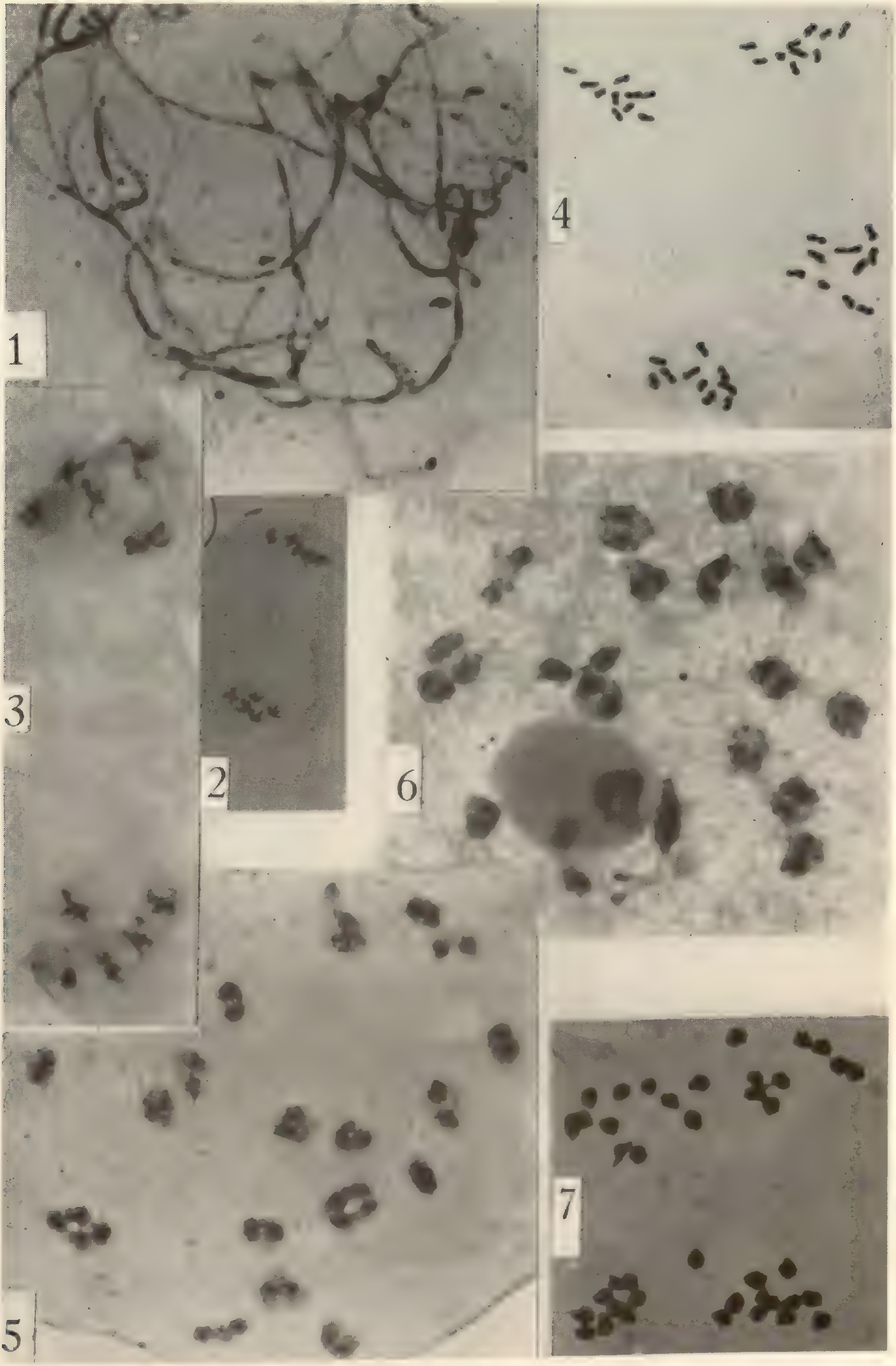
Fig. 3. *Coix poilanei.* Prophase II. × 1150.

Fig. 4. "Blue Adlay." Telophase II.

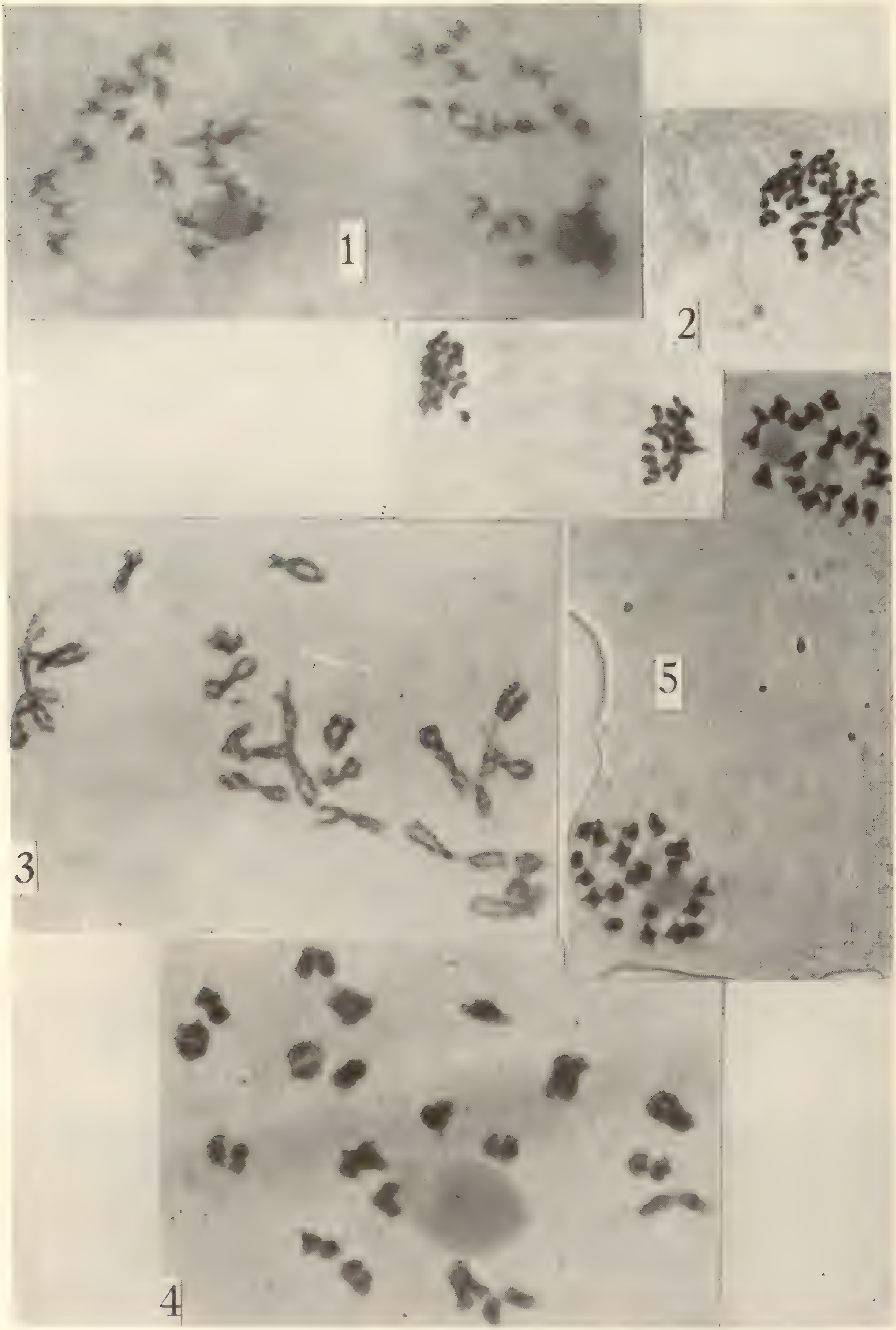
Fig. 5. *Coix gigantea.* Diakinesis showing ring formation. × 1350.

Fig. 6. *Coix gigantea.* Diakinesis showing satellite bivalent. × 1800.

Fig. 7. *Coix gigantea.* Anaphase I. × 1350.



NIRODI—ASIATIC RELATIVES OF MAIZE



NIRODI—ASIATIC RELATIVES OF MAIZE

EXPLANATION OF PLATE

PLATE 13

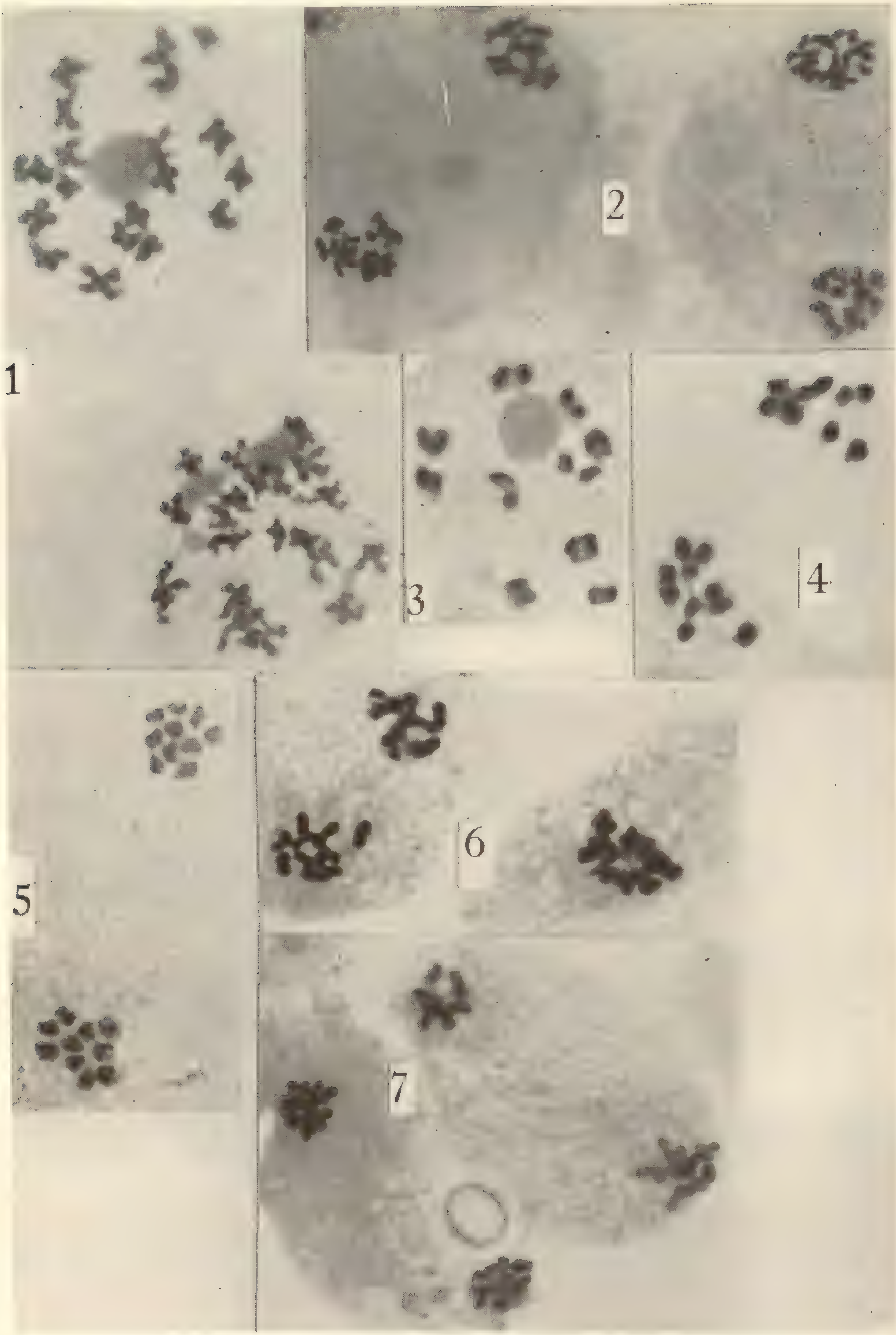
Fig. 1. *Coix gigantea* Koen. ex Roxb. Prophase II showing extra bodies. × 990.

Fig. 2. *Coix gigantea.* Anaphase II. × 1170.

Fig. 3. *Polytoca macrophylla* Benth. Diplotene. × 875.

Fig. 4. *Polytoca macrophylla.* Diakinesis. × 1350.

Fig. 5. *Polytoca macrophylla.* Telophase I. × 1100.



NIRODI—ASIATIC RELATIVES OF MAIZE

Explanation of Plate

PLATE 14

Fig. 1. *Polytoca macrophylla* Benth. Prophase II. × 1170.

Fig. 2. *Polytoca macrophylla.* Telophase II. × 800.

Fig. 3. *Chionachne Koenigii* (Spreng.) Thwaites. Diakinesis.

Fig. 4. *Chionachne Koenigii.* Anaphase I.

Fig. 5. *Chionachne Koenigii.* Telophase I.

Fig. 6. *Chionachne Koenigii.* Anaphase II. × 1550.

Fig. 7. *Chionachne Koenigii.* Telophase II. × 1350.

LICHENOLOGICAL NOTES ON THE FLORA OF THE ANTARCTIC CONTINENT AND THE SUBANTARCTIC ISLANDS. I–IV

CARROLL W. DODGE
AND EMANUEL D. RUDOLPH*

In 1947-1948, the Australian National Antarctic Research Expedition established weather stations at Heard Island and Macquarie Island and somewhat later at Mawson in MacRobertson Land, on the Antarctic Continent. Through the kindness of Dr. H. W. Jessep of the National Herbarium, Melbourne Botanic Garden, and Dr. A. M. Gwynn, Medical Officer and Biologist of the Australian National Antarctic Research Expedition (A.N.A.R.E.), we have had the privilege of studying the lichen collections.

I. Additions to the Lichen Flora of Heard Island

Previous collections were reported by Dodge (1948) based on the British Australian New Zealand Antarctic Research Expedition (B.A.N.Z.A.R.E.), November 27–December 2, 1929, all between Atlas Cove and Corinthian Bay. The weather station was established at Atlas Cove in December 1947 (Scholes, 1951) and closed in 1955. The earlier collections received in 1949 were by D. Alan Gilchrist, Medical Officer; the collector of the later specimens was not recorded on the herbarium labels and are cited: A.N.A.R.E. The island was more accurately mapped in 1948 (A.N.A.R.E. 1949). Most of the southern part of the island is covered by glaciers and ice fields, so that the lichen collections have come from the northwestern part, especially the Cape Laurens peninsula on the northwest corner. Thirty-two species are represented, of which three are new and fifteen have not been previously reported although known from Kerguelen Island to the northwest, making a total of 52 species known from Heard Island.

Thelidium heardense Dodge, B.A.N.Z.A.R.E. Rept. B. 7:44. 1948.

The thallus is lighter (vinaceous buff) than the type, but it agrees microscopically.

North of Cape Laurens on volcanic rock, *A.N.A.R.E. 75.*

Thelidium praevalescens (Nyl.) Zahlbr., Deutsche Südpolar Exp. 8:51. 1906.

Verrucaria praevalescens Nyl., in Crombie, Jour. Linn. Soc. Bot. 15:192. 1876.

As in most previous collections, all of our material is sterile although the thallus has a characteristic appearance.

West Bay, *A.N.A.R.E. 743;* north of Cape Laurens, on broken lava, in cave, *A.N.A.R.E. 67, 72.*

* Graduate Student, Henry Shaw School of Botany of Washington University.

Issued June 23, 1955.

Microglaena kerguelena (Nyl.) Zahlbr., Deutsche Südpolar Exp. 8:51. 1906.

Verrucaria kerguelena Nyl., in Crombie, Jour. Bot. Brit. For. 14:22. 1876.

D. Alan Gilchrist 5, growing with *Steinera Werthii* Zahlbr. New to Heard Island.

Xanthopyrenia **heardensis** Dodge & Rudolph, n. sp.

Type: Heard Island, north of Cape Laurens at base of black cliffs, *A.N.A.R.E. 76*.

Thallus areolatus, areolis 0.3–0.5 mm. diametro subconvexis substipitatisque, marginibus liberis crenulatis, humectatis obscure flavo-viridibus, siccatis flavo-citrinis, homoeomericus; algae *Xanthocapsa*, coloniis sphaericis aut oblongis, vaginis flavo-brunneis, cellulis 7–8 μ diametro; hyphae 2–3 μ diametro inter colonias algarum.

Perithecia immersa, 1–3 in quaque areola, subsphaerica, 200–250 μ diametro, ostiolo minuto; parathecium obscure brunneum, 15–20 μ crassitudine, cellulis polyhedricis; asci 12–15 × 115 μ, leptodermei; ascosporae octonae, imbricatim monostichae, late fusiformes, 19–24 × 8–9 μ, tenui cum halone dum in asco, dein liberae 24 × 10–11 μ, biloculares, cellula superiori majori, hyalinae, septo constrictae.

Thallus areolate, areoles 0.3–0.5 mm. in diameter, slightly convex above, substipitate below, margins free, crenulate, dark yellow-green when moist, old gold to buffy citrine when dry, homoeomerous; algae *Xanthocapsa*, colonies rounded to oblong, of 4–16 cells with a thick yellow-brown sheath at first, becoming densely packed in a homogeneous gel with abundant hyphae and cells more rounded, 7–8 μ in diameter, each with its own sheath about 2 μ thick; hyphae 2–3μ in diameter, filling most of the interstices between the algal cells and colonies.

Perithecia immersed or nearly so, 1–3 per areole, showing as minute dark brown to black points; subspherical, about 200–250 μ in diameter, ostiole small; wall dark brown, 15–20 μ thick, of polyhedral cells; asci 115 × 12–15 μ, thin-walled, 8-spored; ascospores imbricately monostichous, broad fusiform, 19–24 × 8–9 μ, with a thin halo while still in the ascus, 24 × 10–12 μ when free, bilocular, the upper cell larger, hyaline, slightly constricted at the septum.

Steinera glaucella (Tuck.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:66. 1948.

Pannaria glaucella Tuck., Bull. Torrey Bot. Club 6:57. 1875.

Growing with *Placopsis bicolor* (Tuck.) B. de Lesd., on broken lava, north of Cape Laurens, *A.N.A.R.E. 80*. New to Heard Island.

Steinera Werthii Zahlbr., Deutsche Südpolar Exp. 8:43. 1906.

D. Alan Gilchrist 5 and unnumbered specimen.

Lichina antarctica Crombie, Jour. Bot. Brit. For. 14:21. 1876.

On crystalline rock (sandstone?), *A.N.A.R.E.* New to Heard Island.

? Siphulastrum cladinoides Dodge, B.A.N.Z.A.R.E. Rept. B. 7:69. 1948.

We have doubtfully referred our material to this species. It forms compact hemispheric cushions up to 2.5 cm. in diameter. The habit resembles young dense tufts of *Sphaerophorus fragilis* Pers. from the Arctic and Subarctic but it is completely different in structure. The thalli are stiffer than in the type. Although the tips of the ultimate branches become very dark brown, we have been unable to find any reproductive structures. It may represent a new species.

North of Cape Laurens on broken lava, *A.N.A.R.E. 78*. New to Heard Island.

Collemopsidium **pyrenuloides** Dodge & Rudolph, n. sp.

Pl. 15, fig. 3.

Type: Heard Island, north of Cape Laurens, on humus in cave, *A.N.A.R.E. 65*.

Thallus gelifactus, flavidus, siccitate fragillimus, membrano-foliosus, semipellucidus, lobis irregularibus sinibus rotundatis, erectis, subrugosis; homoeomericus; algae Xanthocapsoideae, cellulis 5–6 μ diametro; hyphae sparsae, tenues.

Apothecia lecanorina immersa, 0.4–0.5 mm. diametro; amphithecium non bene evolutum; hypothecium ca. 25 μ crassitudine, hyphis periclinalibus intertextis; thecium 100 μ altitudine; paraphyses 3–4 μ diametro, pachydermeae; asci clavati, juventute apice incrassati; ascosporae octonae, brunneae, late fusiformes, biloculares, septo constrictae, pachydermeae, 25–30 × 10–14 μ.

Thallus a yellowish gel, very fragile when dry, yellow, foliose-membranous, semipellucid, lobes very irregular with somewhat rounded sinuses, erect, subrugose; homoeomerous; algae Xanthocapsoid, cells mostly singly dispersed in the gel without evident sheath, 5–6 μ in diameter, occasionally in small subspherical colonies up to 40 μ in diameter with thin sheaths about each cell and a somewhat thicker sheath surrounding the colonies, best seen in the amphithecium; hyphae very slender, not abundant; some bacterial colonies imbedded in the gel as well as a few moss (?) fragments.

Apothecia lecanorine, immersed or nearly so, about 0.4–0.5 mm. in diameter; amphithecium not clearly differentiated, a zone of Xanthocapsoid colonies with more abundant subvertical hyphae; hypothecium about 25 μ thick, of interwoven periclinal hyphae; paraphyses 3–4 μ in diameter with thick walls, occasionally branched; thecium 100 μ tall; asci clavate, thickened at the tip when young, diffluent, 8-spored; ascospores brown, broad, fusiform, sometimes flattened on one side, bilocular, constricted at the septum, wall thick, protoplasts rounded, rarely 2 distinct protoplasts in each cell, resembling the spores of *Pyrenula*, 25–30 × 12–14 μ.

The thallus suggests the Pyrenopsidaceae, but the algal cells mostly occur singly without an evident sheath and the gel is much softer when moist so that we have been unable to secure good sections. It is possible that the fungus is a parasitic *Tichothecium*, but the mycelium below the hypothecium is continuous with that of the thallus and it lacks a parathecium. Although *C. pyrenuloides* is foliose, it seems more closely related to *Collemopsidium* than to any other genus of the Pyrenopsidaceae.

North of Cape Laurens, on humus in cave, *A.N.A.R.E. 64*, type, *67* sterile.

Pannaria dichroa (Hook. f. & Tayl.) Crombie, Jour. Linn. Soc. Bot. 16:220. 1876.

Lecanora dichroa Hook. f. & Tayl., London Jour. Bot. 3:643. 1844.

Probably owing to the very rough surface of the lava, the lobes are somewhat ascendant and imbricate. The thallus is darker, light brownish olive and not stained with iron. On another very dense rock without locality, nearly covered by *Blastenia keroplasta* Zahlbr., the thallus is quite typical.

D. Alan Gilchrist 3; north of Cape Laurens on broken lava, *A.N.A.R.E. 74.*

Lecidea Auberti B. de Lesd., Ann. Crypt. Exot. 4:99. 1931.

D. Alan Gilchrist 8.

Lecidea assentiens Nyl., in Crombie, Jour. Bot. Brit. For. 13:334. 1875.

North of Cape Laurens, on volcanic rock, *A.N.A.R.E. 75.* New to Heard Island.

Lecidea subassentiens Nyl., in Crombie, Jour. Bot. Brit. For. 14:21. 1876.

D. Alan Gilchrist 4.

Rhizocarpon kerguelense Dodge, B.A.N.Z.A.R.E. Rept. B. 7:116. 1948.

Jacka Valley, on cliffs, *A.N.A.R.E. 33.*

Rhizocarpon Mawsoni Dodge, B.A.N. Z.A.R.E. Rept. B. 7:115. 1948.

D. Alan Gilchrist 7. New to Heard Island.

Rhizocarpon Johnstoni Dodge, B.A.N.Z.A.R.E. Rept. B. 7:118. 1948.

On moraine of Schmidt Glacier, *A.N.A.R.E. 242.* New to Heard Island.

Cladonia phyllophora (Tayl.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:132. 1948.

Cenomyce phyllophora Tayl. in Hook. f. & Tayl., London Jour. Bot. 3:652. 1844.

North of Cape Laurens, *A.N.A.R.E. 70.*

Cladonia Johnstoni Dodge, B.A.N.Z.A.R.E. Rept. B. 7:135. 1948.

Some podetia are nearly clothed with coarse granules, rarely almost isidioid, thus somewhat resembling *C. pyxidata* (L.) Fr.

Among mosses on broken lava, north of Cape Laurens, *A.N.A.R.E. 69.* New to Heard Island.

Argopsis cymosa (Crombie) Stzbgr., Ber. Thätigk. St. Gall. Naturw. Ges. 1889–90:231. 1891.

Stereocaulon cymosum Crombie, Jour. Linn. Soc. Bot. 15:182. 1876.

On broken lava, north of Cape Laurens, *A.N.A.R.E. 71.* New to Heard Island.

Ureceolina kergueliensis Tuck., Bull. Torrey Bot. Club 6:58. 1875.

Jacka Valley, 600 ft., on cliff, *A.N.A.R.E. 34.* New to Heard Island.

ASPICILIA LYGOMMA (Nyl.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:164. 1948.

Lecidea lygomma Nyl. in Crombie, Jour. Bot. Brit. For. 13:334. 1875.

On boulders, 20 ft., West Bay, *A.N.A.R.E. 743*, growing with *Thelidium praevalescens* (Nyl.) Zahlbr. and *Kuttlingeria crozetica* (Zahlbr.) Dodge. New to Heard Island.

ASPICILIA DISJUNGUENDA (Nyl.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:167. 1948.

Lecanora disjunguenda Nyl. in Crombie, Jour. Bot. Brit. For. 15:105. 1877.

D. Alan Gilchrist 6, 7, 9.

ASPICILIOPSIS MACROPHTHALMA (Hook. f. & Tayl.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:175. 1948.

Urceolaria macrophthalma Hook. f. & Tayl., London Jour. Bot. 3:640. 1844.

D. Alan Gilchrist 10.

PLACOPSIS BICOLOR (Tuck.) B. de Lesd. Ann. Crypt. Exot. 4:100. 1931.

Placodium bicolor Tuck., Bull. Torrey Bot. Club 6:57. 1875.

The specimens are much paler than usual, probably from less iron in the rocks, and cephalodia are very rare.

North of Cape Laurens, on broken lava, *A.N.A.R.E. 80*, growing with *Steinera glaucella* (Tuck.) Dodge; on cliff, Jacka Valley, 600 ft., *A.N.A.R.E. 31.*

USNEA TAYLORI Hook. f., London Jour. Bot. 3:657. 1844.

Moraine of Baudessen Glacier, 800 ft., *A.N.A.R.E. 250.* New to Heard Island.

USNEA INSULARIS (Lamb) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:211. 1948.

Neuropogon insularis Lamb, Jour. Linn. Soc. Bot. 52:215. *pl. 8, fig. 17.* 1939.

Only a few plants, beginning to form cupulate apothecia.

Mt. Aubert de la Rüe, 300 ft., *A.N.A.R.E. 4.*

USNEA TRACHYCARPA (Stirton) Müll. Arg. Nuovo Giorn. Bot. Ital. 21:37. 1889.

Neuropogon trachycarpus Stirton, Scottish Nat. 6:105. 1881.

D. Alan Gilchrist 2. New to Heard Island.

BLASTENIA KEROPLASTA Zahlbr., Deutsche Südpolar Exp. 8:28. 1906.

Two specimens without locality, *A.N.A.R.E.* New to Heard Island.

KUTTLINGERIA CROZETICA (Zahlbr.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:226. 1948.

Caloplaca crozetica Zahlbr., Deutsche Südpolar Exp. 8:29. 1906.

Atlas Cove, on rocks above high water, *A.N.A.R.E. 225;* West Bay, 20 ft., *A.N.A.R.E. 743;* on cliff in Jacka Valley, 600 ft., *A.N.A.R.E. 32; D. Alan Gilchrist 1.* New to Heard Island.

BUELLIA SUBPLICATA (Nyl.) Müll. Arg., Bot. Jahrb. [Engler] 5:138. 1884.

Lecidea subplicata Nyl. in Crombie, Jour. Bot. Brit. For. 13:334. 1875.

On cliff, Jacka Valley, *A.N.A.R.E. 33.*

Rinodina aspicilina Zahlbr., Deutsche Südpolar Exp. 8:50. 1906.

Two small specimens without locality, *A.N.A.R.E.*

DEUTEROLICHENES (LICHENES IMPERFECTI)

Occasionally lichenologists have encountered conidial fructifications on lichen thalli, sometimes associated with apothecia, sometimes not. Müller-Argau (1881) described an otiform conidial structure which he named a campylidium. Vainio (1890) found the same structure on a thallus of *Lopadium perpallida* (Nyl.) Zahlbr. (*Lecidea perpallida* Nyl.) and referred it to *Cyphella aeruginascens* Karst. Spegazzini (1909) named it as a genus of lichenes imperfecti, *Chlorocyphella,* based on *C. subtropica* Speg. Keissler (1927) transferred *Cyphella aeruginascens* Karst. and described several new varieties. Mameli Calvino (1930) proposed the name Deuterolichenes to include *Chlorocyphella,* and Cengia Sambo (1937, 1941) and Rizzini (1952) have reported species of *Chlorocyphella* not associated with apothecia. Malme (1935) considered *C. aeruginascens* (Karst.) Keissl. to be a conidial stage of *Lopadium perpallidum* (Nyl.) Zahlbr., and Dodge (1953) described a campylidium as a conidial state of *L. Deightoni* Dodge. Campylidia have also been observed on *Sporopodium* sp.

Müller-Argau (1890) described another type of fructification, the orthidium, which resembles an apothecium except that the thecium is replaced by conidiophores, and the senior author has seen a similar fructification on a foliicolous thallus from Jamaica. Our material contains an orthidium-bearing lichen from Heard Island, resembling *Ephelis* Fr. of the Excipulaceae, which has unicellular spores, while those of our lichen become septate as do those of *Ephelis trinitensis* Cooke & Massee, the imperfect state of *Balansia trinitensis* Cooke & Massee on *Panicum palmifolium* in Trinidad, B.W.I.

EPHELIDIUM Dodge & Rudolph, n. gen.

Type: *Ephelidium heardense* Dodge & Rudolph.

Thallus crustosus, indeterminatus, sorediosus, ecorticatus, heteromericus; algae protococcoideae. Orthidium sessile, concavum, margine persistente; conidiophorae simplices; conidia singulatim disposita, terminalia, acicularia, septata.

Thallus crustose, indeterminate, sorediose, ecorticate, heteromerous; algae protococcoid. Orthidium sessile, concave with a persistent margin, resembling a lecanorine (or biatorine as the algae die above) apothecium; conidiophores unbranched; conidia single, terminal, acicular, long remaining unicellular but finally multiseptate.

Ephelidium **heardense** Dodge & Rudolph, n. sp. Pl. 15, fig. 1.

Type: Heard Island, Atlas cove at foot of *Poa* mound, *A.N.A.R.E. 147*.

Thallus crustosus, indeterminatus, 0.7–1.2 mm. crassitudine, citrinus, sorediosus; ecorticatus; stratum algarum ca. 280 μ crassitudine, cellulis protococcoideis, 8.7–12.2 μ diametro; medulla crassa, hyphis 1 μ diametro dense intertextis, nubilatis.

Orthidium sessile, basi constrictum, orbiculare, 0.6–1.5 mm. diametro, subochraceum, margine 250–280 μ crassitudine; conidiophorae tenues, unicellulares, 13–17 μ longitudine; conidia singulatim disposita, acicularia, hyalina, 30–44 × 2 μ, primum unicellulares, dende ad 7-septata, recta aut subcurvata.

Thallus crustose, indeterminate, 0.7–1.2 mm. thick, buffy citrine, sorediose, K orange brown, C—; ecorticate; algal layer about 280 μ thick, cells protococcoid, spherical to somewhat polyhedral from mutual pressure, 8.7–12.2 μ in diameter; medulla thick, of closely woven hyphae about 1 μ in diameter, somewhat nubilated with granules and including pieces of roots etc. from the substrate.

Orthidium sessile, constricted at the base, circular, 0.6–1.5 mm. in diameter, ochraceous buff, disc very concave; margin 250–280 μ thick, finally undulate; algae in a discontinuous layer on the outside of the layer of conidiophores, tending to die out above and forming a continuous layer below; the medulla around and between the algal colonies is formed of compactly woven hyphae about 1 μ in diameter; conidiophores arising from the medullary hyphae, forming a continuous layer 13–17 μ thick; conidia borne singly, acicular, 30–44 × 2 μ, hyaline, nonseptate until late, finally up to 7-septate, straight or slightly curved, slightly tapering at the ends.

II. Additions to the Lichen Flora of Macquarie Island

Previous collections were reported by Dodge (1948). Most of the present collections are from the northern half of the island, collected mostly by Norman R. Laird and by N. M. Haysom of the A.N.A.R.E. Taylor (1954) has discussed the problem of distribution of the flowering plants which apparently have much wider ranges than the lichens. Twenty-seven species are reported from the present collection, three of which are new and three not previously reported bringing the total species of lichens to forty-four. Several other possible new species will be reported in a later number of these Lichenological Notes. In the following list *MI/49/* has been omitted from N. M. Haysom's numbers of collections.

Microthelia macquariensis Dodge, B.A.N.Z.A.R.E. Rept. B. 7:48. 1948. Plateau, 800 ft., between Mt. Elder and Sandy Bay, *N. M. Haysom Z8.*

Coenogonium subtorulosum Müll. Arg., Jour. Linn. Soc. Bot. 32:207. 1896. Orange red when fresh, drying olive buff. The *Trentepohlia* filaments have very few corticating hyphae. From glacial moraine above Sandy Bay, 500 ft., *N. M. Haysom Z2.*

Psoroma versicolor (Hook. f. & Tayl.) Müll. Arg., Flora 71:538. 1888.

Lecanora versicolor Hook. f. & Tayl., London Jour. Bot. 3:642. 1844, non Ach.

The squamules are less well developed than in previous collections but the apothecia agree microscopically.

Norman R. Laird 2, 2a, 2c; Featherbed Terrace, growing over decaying hepatics and other vegetable debris, *A.N.A.R.E.*

Pseudocyphellaria glabra (Hook. f. & Tayl.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:79. 1948.

Stricta glabra Hook. f. & Tayl., London Jour. Bot. 3:647. 1844.

South end of Plateau, on moss, *N. M. Haysom Z114;* north end of Plateau, on soil and over decaying mosses, *Norman R. Laird;* Featherbed Terrace, *A.N.A.R.E.;* Wireless Hill, *N. M. Haysom Z1;* north of Lusitania Bay, *N. M. Haysom Z134.*

Peltigera **Lairdi** Dodge & Rudolph, n. sp.

Type: Macquarie Island, growing on soil over decaying grasses, mosses and hepatics, *Norman R. Laird 4, A.N.A.R.E.*

Thallus foliosus, in herbario isabellinus, ad 10 cm. diametro, 400 μ crassitudine, lobis sterilibus ca. 1.5 cm. latitudine, 2 cm. longitudine; tomentum crassum, verrucosum in partibus junioribus; superficies inferior arachnoideus inter venas; venae sparsae, elevatae, arachnoideo-tomentosae, rhizinis simplicibus vel semel dichotome ramosis, ca. 5 mm. longitudine, concoloribus; cortex ca. 90 μ crassitudine, pseudoparenchymaticus, cellulis 12–15 μ diametro leptodermeis; stratum algarum 50–55 μ crassitudine, cellulis nostocaceis, 5 μ diametro; medulla 270 μ crassitudine, hyphis periclinalibus pachydermeis, 4 μ diametro, parte superiore compacta, inferiore laxiore, hyphis ad 8 μ diametro, lumine 5 μ.

Apothecia in lobis erectis non revolutis, 15 mm. altitudine, 5–6 mm. latitudine, sita; discus nigro-brunneus, 4 mm. diametro; sine amphithecio nec parathecio, stratum algarum sub hypothecio crassiore, ad 120 μ crassitudine; hypothecium 30 μ crassitudine, brunneum, superne obscurius, pseudoparenchymaticum, hyphis periclinalibus; thecium 120–130 μ altitudine; paraphyses simplices, ca. 2 μ diametro; asci 100–105 × 11–12 μ, juventute apice incrassati; ascosporae octonae, hyalinae, aciculares, multiseptatae, ca. 56 × 3 μ.

Thallus foliose, becoming isabella color in the herbarium, up to 10 cm. in diameter, 400 μ thick, margin lobed, sterile lobes about 1.5 cm. wide and 2 cm. long, somewhat lacerate on drying, ends of lobes with thick, verrucose tomentum above, becoming smooth but surface dull in the older portions as the tomentum weathers away; underside pinkish buff, arachnoid between the sparse veins; veins elevated, arachnoid-tomentose; rhizinae not abundant, simple or once-dichotomous near the tips, about 5 mm. long, concolorous; cortex about 90 μ thick, pseudoparenchymatous, cells rather thin-walled, 12–15 μ in diameter; algal layer 50–55 μ thick, of *Nostoc* colonies, cells about 5 μ in diameter in an inconspicuous gel; medulla 270 μ thick, of closely packed periclinal hyphae, thick-walled, about 4 μ in diameter, less compact and more irregularly arranged below, forming the arachnoid underside with hyphae up to 8 μ in diameter, lumen 5 μ.

Apothecia on erect lobes, not revolute, 15 mm. tall, 5–6 mm. wide, disc very dark brown, 4 mm. in diameter; no amphithecium nor parathecium differentiated; algal layer thicker below the hypothecium, up to 120 μ thick; hypothecium 30 μ thick, lower half pale brown, upper half very dark brown, pseudoparenchymatous from periclinal hyphae; thecium 120–130 μ tall; paraphyses about 2μ in diameter, unbranched, tips ending in the dark brown epithecial gel; asci 100–105 × 11–12 μ,

tips slightly thickened when young, 8-spored; ascospores hyaline, acicular, 56 × 3 μ, thin-walled, many septate.

This species somewhat resembles *Peltigera dilacerata* Gyelnik from Auckland, New Zealand, which has longer and narrower lobes with dilacerate margins and is about half as thick.

Lecidea subglobulata Knight, Trans. Proc. N. Zeal. Inst. 8:314. 1875 [1876].

South slopes of Wireless Hill, *A.N.A.R.E.* New to Macquarie Island.

Catillaria (Eucatillaria) **Rudolphi** Dodge, n. sp.

Type: Macquarie Island, without locality, but the rock types closely resemble those from the south slopes of Wireless Hill, *A.N.A.R.E.*

Thallus crustosus, albidus, continuus aut ad centrum areolatus crassior, margine irregulariter lobatus; cortex fastigiatus subdecompositus, erosus, ad 30 μ crassitudine; stratum algarum 65 μ crassitudine, cellulis protococcoideis 6–8 μ diametro; medulla 250–300 μ crassitudine, hyphis tenuibus, granulis brunneis nubilatis, dense contexta.

Apothecia subimmersa aut sessilia, ad 2.5 mm. diametro, orbicularia, aut mutua pressione angularia, margine elevato, disco plano aut subconvexo nigro; parathecium carbonaceum, in margine 50 μ crassitudine ad 125–160 μ sub thecio; hypothecium non bene evolutum; thecium 90–120 μ altitudine; paraphyses tenues, septatae, super ascos ramosae, apicibus clavatis brunneis, ca. 1.5 μ diametro; asci 50–60 × 7–8.5 μ, cylindrico-clavati, leptodermei; ascosporae octonae, hyalinae, biloculares, uniseriales, ellipsoideae, 13–15 × 6–7 μ.

Thallus whitish, sometimes stained ferruginous from iron in the underlying rock, thin, continuous at the margin, thicker toward the areolate center, K yellow then orange, margin irregularly lobate, distinct; cortex fastigiate, somewhat decomposed and eroded, up to about 30 μ thick; algal layer 65 μ thick, cells protococcoid, 6–8 μ in diameter in a continuous dense layer; medulla 250–300 μ thick, of densely woven slender hyphae, heavily nubilated with dark brown granules.

Apothecia slightly immersed to sessile, up to 2.5 mm. in diameter, abundant, circular or angular from mutual pressure, margins elevated, disc plane to slightly convex, black; parathecium carbonaceous, 50 μ thick at the margin, 125–160 μ thick below the thecium; hypothecium not clearly differentiated; thecium 90–120 μ tall; paraphyses slender, septate, branched at the level of the tips of the asci, tips slender, clavate, brownish, about 1.5 μ in diameter, asci 50–60 × 7–8.5 μ, cylindric-clavate, thin-walled, 8-spored; ascospores hyaline, bilocular, mostly uniseriate, ellipsoidal, 13–15 × 6–7 μ.

The germinating ascospore produces an extensive black hypothallus. As contact is made with algal cells, thin assimilative areoles develop and finally fuse, covering the hypothallus as a continuous thallus which gradually thickens with age.

Without locality but probably from south slopes of Wireless Hill, *A.N.A.R.E.*, type; west side of Wireless Hill, *N. M. Haysom Z152;* south end of Plateau, *N. M.*

Haysom Z137; Plateau, 900 ft., young, *A.N.A.R.E.;* north end of Plateau, *N. M. Haysom Z86;* without locality, *Norman R. Laird 8.*

CLADIA AGGREGATA (Sw.) Nyl., Bull. Soc. Linn. Normand. II, 4:167. 1870.

Lichen aggregatus Sw., Nova Gen. Sp. Pl. Ind. Occ. 147. 1788.

West coast, fluviatile swamp, 50 ft., *A.N.A.R.E.*

CLADONIA FLORIFORMIS Dodge, B.A.N.Z.A.R.E. Rept. B. 7:134. 1948.

Wireless Hill, 300 ft., *Norman R. Laird 1d;* Nuggets Creek, *Norman R. Laird 1a, 1b,* young; without locality, *Norman R. Laird 1;* only a few young plants among mosses, *A.N.A.R.E. 5c.*

CLADONIA MAWSONI Dodge, B.A.N.Z.A.R.E. Rept. B. 7:128. 1948.

Nuggets Valley, 100 ft., *A.N.A.R.E.;* ? primary thallus only, mouth of cave, south end of isthmus, *A.N.A.R.E.*

CLADONIA SARMENTOSA (Tayl.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:129. 1948.

Cenomyce sarmentosa Tayl. in Hook. f. & Tayl., London Jour. Bot. 3:651. 1844.

Interior of cave, 35 ft., *A.N.A.R.E.;* near Brothert Point, 250 ft., *A.N.A.R.E.;* near Nuggets Creek, *Norman R. Laird 1c, 1d, 2c;* Lusitania Valley, east coast, 150 ft., *A.N.A.R.E.*

STEREOCAULON ARGODES Nyl., Compt. Rend. Acad. Sci. [Paris] 83:88. 1876.

Stereocaulon Argus Th. Fr., Nova Acta R. Soc. Sci. Upsal. III, 2^1:333. 1858; Hook. f. & Tayl., London Jour. Bot. 3:653. 1844, pro parte min.

For discussion of nomenclature, see Dodge (1948, pp. 142–144) sub *Argopsis megalospora.* In the present collection the dimensions of the ascospores are somewhat greater, 45–53 $\times$5.5–7 μ, than those given by Th. M. Fries and Nylander.

On coastal vegetation north of Lusitania Bay, *N. M. Haysom Z128;* Plateau, *N. M. Haysom Z1.*

STEREOCAULON PULVINARE Dodge, B.A.N.Z.A.R.E. Rept. B. 7:139. 1948.

Near Nuggets Creek, *Norman R. Laird.*

STEREOCAULON SUBMOLLESCENS Nyl., Compt. Rend. Acad. Sci. [Paris] 83:88. 1876.

Featherbed Terrace, *A.N.A.R.E.;* north end of Plateau, *N. M. Haysom Z85.*

PERTUSARIA TYLOPLACA Nyl. Compt. Rend. Acad. Sci. [Paris] 83:90. 1876.

South end of Plateau, *N. M. Haysom Z122;* Plateau, 900 ft., *A.N.A.R.E.;* north end of Plateau, *N. M. Haysom Z59, Z62;* growing over *Menegazzia circumsorediata* Santesson on radio mast erected by A.A.E. in 1911 on Wireless Hill, *A.N.A.R.E.*

PLACOPSIS PERRUGOSA (Nyl.) Nyl., Lich. Nov. Zelandiae, 57. 1888.

Lecanora perrugosa Nyl., Flora 48:338. 1865.

For complete description, see I. M. Lamb, Lilloa 13:268–272. 1947.

On rocky banks of Lusitania Creek, *N. M. Haysom Z123*. New to Macquarie Island.

THAMNOLECANIA **macquariensis** Dodge & Rudolph, n. sp.

Type: Macquarie Island, Wireless Hill, on cliff subject to water seepage, *A.N.A.R.E.*

Thallus fruticosus erectus aut subdecumbens, pulvinos hemisphaericos ad 3 cm. diametro formans, di- aut tri-chotome ramosus, torulosus, cinnamomeo-alutaceus, inferne ad 0.8 mm. diametro, superne tenuior, ad 1 cm. altitudine; ecorticatus; algae flavo-virides, cellulis sphaericis vel mutua pressione polyhedricis, 8–11 μ diametro; hyphae medullares ca. 3 μ diametro, conglutinatae, inter cellulas algarum.

Apothecia ad 1 mm. diametro in lateribus ramorum sessilia, plana dein convexa emarginataque, ca. 250 μ altitudine, disco nigro; amphithecium 250 μ crassitudine; parathecium non bene distinctum, margine ad 40 μ crassitudine; hypothecium obconicum, ca. 190 μ altitudine, hyphis verticalibus nigro-brunneis; thecium 135 μ altitudine; paraphyses 2.5–3 μ diametro, septatae, cellula terminali clavata 4 $\times$ 5.5 μ, pachydermea nigro-brunnea; asci ca. 65 $\times$ 12 μ, clavati, juventute apice incrassati; ascosporae octonae, subdistichae in ascis 16 $\times$ 8 μ, biloculares, brunneae, septo tenui constrictae, liberatae, 12 $\times$ 6 μ, nigro-brunneae.

Thallus fruticose, erect or subdecumbent, forming dense, depressed hemispheric cushions up to 3 cm. in diameter, branching di- or trichotomous, torulose, pinkish buff to cinnamon buff, up to 0.8 mm. in diameter below, more slender above, circular in cross-section, about 1 cm. tall; ecorticate; algae yellow-green, spherical or somewhat polyhedric from mutual pressure in the outer portion, 8–11 μ in diameter with a thick sheath of periclinal medullary hyphae, more scattered throughout the medulla; hyphae about 3 μ in diameter, compact and conglutinate between the algal cells.

Apothecia up to 1 mm. in diameter, sessile on the sides of the branches, not on the ultimate branches, flat at first becoming convex and emarginate, about 250 μ tall, disc black; amphithecium about 250 μ thick, similar in structure to that of the thallus but the medullary hyphae more vertical; parathecium not well differentiated, about 40 μ thick at the margin, scarcely differentiated from the paraphyses, continuous below with the dark brown obconic hypothecium about 190 μ tall at the center, of vertical dark brown hyphae, not sharply differentiated from the thecium above; thecium 135 μ tall; paraphyses 2.5–3 μ in diameter, septate, terminal cell broadly clavate, about 4 $\times$ 5.5 μ, thick-walled, dark brown above; asci about 65 $\times$ 12 μ, clavate, tips very thick when young, 8-spored; ascospores subdistichous, 16 $\times$ 8 μ, bilocular, brown, ellipsoid, slightly constricted at the thin septum, shrinking to 12 $\times$ 6 μ when free from the ascus and very dark brown.

The specimens have been cut from the underlying rock, but the cut ends suggest that the base may expand into a circular holdfast. The systematic position of this species is not clear. The bilocular brown spores with a thin septum, the paraphyses and lecanorine apothecium suggest *Rinodina* sect. *Beltraminia;* the very dark hypothecium suggests *Melanaspicilia* Vainio. From both of these it differs in

its fruticose thallus. The structures of the thallus and of the apothecia are wholly different from those of the fruticose species of *Anaptychia*, but do resemble those of *Thamnolecania* from which it differs in a very dark brown hypothecium and broader brown bilocular spores. Its yellowish green algae suggest a relationship to *Thelidea* Hue, which is foliose with biatorine apothecia and hyaline ascospores. It is not a parasite as the medullary hyphae are continuous with those at the base of the hypothecium and the amphithecium is well developed; hence it cannot be considered a *Karschia* sp. on a *Siphula*.

Parmelia turgidula Bitter, Hedwigia 40:246. 1901.

Featherbed Terrace, over mosses. A single sterile plant. New to Macquarie Island but previously known from New Zealand.

Parmelia sublugubris Dodge, B.A.N.Z.A.R.E. Rept. B. 7:188. 1948.

Featherbed Terrace, *A.N.A.R.E.; Norman R. Laird 3;* north end of Plateau, *N. M. Haysom Z61.*

Parmelia tenuirima Hook. f. & Tayl., London Jour. Bot. 3:645. 1844.

Featherbed fluviatile terrace on northwest slopes, growing over mosses, *Norman R. Laird;* from rock face, Half Moon Bay, west coast, *A.N.A.R.E.*

Menegazzia circumsorediata Santesson, Ark. f. Bot. 30:11:14. 1942.

Thallus 9 cm. in diameter. Wireless Hill, on radio mast erected by the A.A.E. in 1911, *A.N.A.R.E.;* coastal rocks north of Lusitania Bay, *N. M. Haysom Z127.*

Usnea arida v. muscicola Dodge, B.A.N.Z.A.R.E. Rept. B. 7:207. 1948.

Wireless Hill, on planks of A.A.E. radio hut, *N. M. Haysom Z53.*

Usnea contexta Motyka, Lich. Gen. Usnea Stud. Monog. 2:436. 1937.

Featherbed Terrace, *A.N.A.R.E.;* north end of Plateau, *N. M. Haysom Z83.*

Usnea torulosa (Müll. Arg.) Zahlbr., Cat. Lich. Univ. 6:594. 1930.

Usnea dasypogoides f. *torulosa* Müll. Arg., Flora 66:19. 1883.

Our plants are only 3 cm. tall with shorter lower internodes. North of Lusitania Bay, *N. M. Haysom Z130.*

Usnea xanthopoga Nyl., Compt. Rend. Acad. Sci. [Paris] 83:89. 1876.

Among mosses, *Norman R. Laird 5a, 5b, 5c, 5d, 5e;* Featherbed Terrace, very young, *A.N.A.R.E.*

Ramalina geniculata Hook. f. & Tayl., London Jour. Bot. 3:665. 1844.

Turf from rock surface, west coast, 50 ft., *A.N.A.R.E.;* Featherbed Terrace, *A.N.A.R.E.*

Gasparrinia macquariensis Dodge, B.A.N.Z.A.R.E. Rept. B. 7:234. 1948.

One plant has much larger apothecia, up to 4 mm. in diameter, with flat discs and nearly excluded margins but agrees microscopically.

Hasselborough Bay, isthmus beach, *Norman R. Laird 8a;* beach of Garden Cove, *N. M. Haysom Z11, Z223;* Green Gorge, *N. M. Haysom Z102.*

Buellia Mawsoni Dodge, B.A.N.Z.A.R.E. Rept. B. 7:243. 1948.
South end of Plateau, *N. M. Haysom Z137.*

III. Flora of Adélie Land

A small collection was received from Cape Margerie, 66° 50′ S., 141° 20′ E., collected on November 4, 1950, the first specimens taken from Adélie Land. Since the collection is small and Adélie Land lies between King George V Land and Queen Mary Land, it is not surprising that all these species have been reported before.

Umbilicaria Hunteri Dodge, B.A.N.Z.A.R.E. Rept. B. 7:148. 1948.
A.N.A.R.E. 4. Previously known from King George Land.

Alectoria congesta (Zahlbr.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:195. 1948.
Parmelia pubescens v. *congesta* Zahlbr., Deutsche Südpolar Exp. 8:52. 1906.
A.N.A.R.E. 3. Previously known from King George V Land to MacRobertson Land.

Usnea antarctica DuRietz, Svensk Bot. Tidskr. 20:90, 93. 1926.
A.N.A.R.E. 6. Previously known from Marie Byrd Land to King George V Land.

Usnea pustulata Dodge, B.A.N.Z.A.R.E. Rept. B. 7:203. 1948.
A.N.A.R.E. 5a. Previously known from King George V Land and Queen Mary Land.

Usnea scabridula (Lamb) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:204. 1948.
Neuropogon acromelanus v. *inactivus* f. *scabridulus* Lamb, Jour. Linn. Soc. Bot. 52:220. 1939.
A.N.A.R.E. 5. Previously known from South Victoria Land to King George V Land.

Xanthoria Mawsoni Dodge, B.A.N.Z.A.R.E. Rept. B. 7:236. 1948.
A.N.A.R.E. 1. Previously known from King George V Land to MacRobertson Land.

Rinodina frigida (Darb.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:259. 1948.
Buellia frigida Darb., Brit. Nat. Antarct. "Discovery" Exp. Nat. Hist. 5:Lich.:7. 1910.
A.N.A.R.E. 3. Previously known from Marie Byrd Land to MacRobertson Land.

IV. Additions to the Flora of MacRobertson Land

Previous collections from Cape Bruce were reported by Dodge (1948). The present collections are from the A.N.A.R.E. weather station at Mawson, about 67° S. and 50° E., collected by the Medical Officer, Dr. A. M. Gwynn. Fourteen species are represented, one new species, six others new to MacRobertson Land,

making twenty-four species so far known. The Verrucariaceae are still absent from collections.

Heppia antarctica Dodge, B.A.N.Z.A.R.E. Rept. B. 7:71. 1948.

Small sterile thalli along with several genera of Myxophyceae on a weathered crystalline rock with *Parmelia Johnstoni* Dodge, *A. M. Gwynn Li23.*

Lecidea Harrissoni Dodge, B.A.N.Z.A.R.E. Rept. B. 7:101. 1948.

On rock with *Alectoria congesta* (Zahlbr.) Dodge, *A. M. Gwynn Li29.*

Umbilicaria spongiosa v. subvirginis (Frey & Lamb) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:148. 1948.

Umbilicaria antarctica v. *subvirginis* Frey & Lamb, Trans. Brit. Myc. Soc. 22:272. 1939.

Thallus about 7 cm. in diameter, upper surface pale smoke-gray or lighter, very minutely rimulose.

A. M. Gwynn Li30. New to MacRobertson Land.

Umbilicaria subcerebriformis Dodge, B.A.N.Z.A.R.E. Rept. B. 7:149. 1948.

A. M. Gwynn Li30. New to MacRobertson Land.

Acarospora (Pachnolepia) **Gwynni** Dodge & Rudolph, n. sp.

Pl. 15, fig. 2.

Type: MacRobertson Land, Mawson, on weathered reddish granite? *A. M. Gwynn Li21.*

Thallus cerebriformis subfruticulosus, juventute citrinus dein magis olivaceo-viridis, ad 3 mm. diametro, substipitatus, marginibus liberis, ca. 500 μ crassitudine, inferne alutaceus; cortex superne 20–25 μ inferne ad 30 μ crassitudine, fastigiatus, pseudoparenchymaticus, cellulis pachydermeis, luminibus 2.5 μ diametro, strato amorpho gelifacto 15 μ crassitudine tectus; algae protococcoideae, cellulis 13–14 μ diametro; medulla non distincte evoluta, hyphis 2 μ diametro.

Apothecia ca. 0.5 mm. diametro, orbicularia vel mutua pressione elliptica, immersa, disco obscuro; parathecium hyalinum, 15 μ crassitudine in lateribus thecii, subtus 25–30 μ crassitudine, hyphis periclinalibus; hypothecium 15 μ crassitudine, hyphis tenuibus grumosis dense contextum; thecium 230 μ altitudine; paraphyses cohaerentes, distinctae, pachydermeae, 2 μ diametro; asci 100 $\times$ 20 μ, juventute apice incrassati; ascosporae multae, ellipsoideae, ca. 3.5 $\times$ 1.8 μ (liberae non visae).

Spermogonia immersa, 200 μ diametro; perifulcrum hyalinum, 15 μ crassitudine, hyphis pachydermeis, periclinalibus conglutinatis; fulcrum in cavitate invaginans; spermatiophorae 12–15 μ longitudine, subramosae (modo *Cladoniae*); spermatia hyalina, anguste ellipsoideae, 3 $\times$ 1 μ.

Thallus cerebriform, subfruticulose, lemon-yellow in younger portions to warbler green when the apothecia are well developed, covering areas up to 2 cm. in diameter, individual thalli up to 3 mm. in diameter, attached at the center, margins free, about 500 μ thick, upper surface smooth to deeply furrowed and cerebriform, under surface warm-buff, K—; cortex 20–25 μ above to 30 μ thick below, completely surrounding the thallus, fastigiate, of thick-walled pseudo-

parenchyma, cell lumina 2.5 μ in diameter, densely nubilated with minute yellowish crystals, especially above, covered by an amorphous layer of gel about 15 μ thick, with scattered granules; algal layer filling the thallus between the cortices, cells protococcoid, 13–14 μ in diameter, often polyhedral from mutual pressure; medulla not differentiated, hyphae about 2 μ in diameter between the algal cells.

Apothecia very numerous in the central thalli, about 0.5 mm. in diameter, circular to somewhat elliptic from mutual pressure, immersed, disc greenish black; amphithecium not differentiated from the thallus, but often with a circular furrow about 0.2 mm. from the parathecium; parathecium hyaline, of periclinal hyphae about 15 μ thick at the sides of the thecium to 25–30 μ thick below; hypothecium about 15 μ thick, of grumose, densely woven, slender hyphae; thecium 230 μ tall, the upper 25 μ brownish and covered by a hyaline amorphous gel about 13 μ thick; paraphyses coherent, distinct, thick-walled, about 2 μ in diameter; asci about 100 × 20 μ, tips thickened when young; ascospores numerous, ellipsoid, about 3.5 × 1.8 μ (not seen free from ascus).

Spermogonia immersed, about 200 μ in diameter, wall hyaline, 15 μ thick, of thick-walled, conglutinate, periclinal hyphae; layer of spermatiophores invaginated, forming cerebriform cavities, spermatiophores 12–15 μ long, somewhat branched (*Cladonia* type); spermatia hyaline, narrow ellipsoid, about 3 × 1 μ.

On weathered reddish granite, *A. M. Gwynn Li21, Li27.*

LECANORA GRISEOMARGINATA Dodge & Baker, Ann. Mo. Bot. Gard. 25:572. 1938.

Growing on moss cushion, *A. M. Gwynn Li20.* New to MacRobertson Land.

LECANORA EXSULANS (Th. Fr.) Dodge & Baker, Ann. Mo. Bot. Gard. 25:570. 1938.

Lecanora chrysoleuca v. *melanophthalma* f. *exsulans* Th. Fr., Nyt Mag. Naturvidensk. 40:208. 1902.

A. M. Gwynn Li21, Li24, Li38, Li31 (a single young plant not sectioned).

PARMELIA JOHNSTONI Dodge, B.A.N.Z.A.R.E. Rept. B. 7:191. 1948.

Growing over weathered rocks and mosses, *A. M. Gwynn Li21, Li22, Li23, Li25, Li28, Li31.*

ALECTORIA CONGESTA (Zahlbr.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:195. 1948.

Parmelia pubescens v. *congesta* Zahlbr., Deutsche Südpolar Exp. 8:52. 1906.

On rock, *A. M. Gwynn Li29.*

PROTOPLASTENIA CITRINA Dodge, B.A.N.Z.A.R.E. Rept. B. 7:222. 1948.

The color is more orange than in the type and all the material is sterile, although the thallus agrees microscopically.

Growing over moss cushions, *A. M. Gwynn Li20, Li21, Li25.*

Gasparrinia Harrissoni Dodge, B.A.N.Z.A.R.E. Rept. B. 7:235. 1948.

Thallus about 5 cm. long and 2 cm. wide, apparently starting near the edge of the rock fragment, so probably capable of forming a circular thallus about 5 cm. in diameter when the substrate permits. *A. M. Gwynn Li26, Li31,* a smaller thallus.

Xanthoria Mawsoni Dodge, B.A.N.Z.A.R.E. Rept. B. 7:236. 1948.

A. M. Gwynn Li20, Li28, Li32.

Buellia Johnstoni Dodge, B.A.N.Z.A.R.E. Rept. B. 7:249. 1948.

A. M. Gwynn Li28, associated with *Lecanora exsulans* (Th. Fr.) Dodge & Baker, as in the type. New to MacRobertson Land.

Rinodina frigida (Darb.) Dodge, B.A.N.Z.A.R.E. Rept. B. 7:259. 1948.

Buellia frigida Darb., Brit. Nat. Antarct. "Discovery" Exp., Nat. Hist. 5:Lich.:7. 1910.

A. M. Gwynn Li21, with lecanorine apothecia nearly immersed; *Li27, Li33,* larger older thallus up to 6 cm. in diameter.

Nostoc sp.

Several thalli growing on a moss cushion, akinetes abundant. A few young perithecia or cleistothecia were seen which may be parasites, or perhaps the thalli are those of a Pyrenidiaceous lichen. Very few fungus hyphae were seen in the gel between the algal filaments but in one or two places there is a faint suggestion of a cortex. Some thalli contained a few bacterial colonies. We hope it will be found again in a more mature condition, if it be a lichen.

A. M. Gwynn Li20, along with *Lecanora griseomarginata* Dodge & Baker and sterile *Protoblastenia citrina* Dodge.

BIBLIOGRAPHY

Australian National Antarctic Research Expedition (1949). [Map of] Heard Island from survey by Australian National Antarctic Research Expedition, 1948, scale 1:83,000.

Cengia Sambo, Maria (1937). Lichenes Africae Orientalis Italicae. Nuovo Giorn. Bot. Ital. N.S. 44:456–473. *3 figs.* [see p. 470].

————, (1941). Fragmenta lichenologica III. Ibid. 48:495–516. [see p. 500–501].

Dodge, Carroll W. (1948). Lichens and lichen parasites. British Australian New Zealand Antarctic Research Expedition (B.A.N.Z.A.R.E.) Rept. B. 7:1–276.

————, (1953). Some lichens of tropical Africa. Ann. Mo. Bot. Gard. 40:271–401. [see pp. 362–363].

Keissler, K. v. (1927). Systematische Untersuchungen über die Flechtenparasiten und lichenoide Pilze. V. Ann. Naturhist. Mus. Wien 41:157–170. [see p. 157–163].

Malme, G. (1935). Das Kampylidium, ein verkanntes Fortpflanzungsorgan der Flechten. Svensk Bot. Tidskr. 29:302–305.

Mameli-Calvino, Eva (1930). Ricerche su una forma singolare di Deuterolicheni: *Chlorocyphella subtropica* Speg. Nuovo Giorn. Bot. Ital. N.S. 37:369–379. *pl. 19.*

Müller-Argau, J. (1881). Lichenologische Beiträge. XII (Schluss). Flora 64:100–112. [see p. 111–112].

————, (1890). Lichenologische Beiträge. XXXIII. Ibid. 73:187–202. [see p. 202].

Rizzini C. Toledo (1952). Lichenes in Horto Botanico Fluminis Januarii crescentes. I. Arq. Jard. Bot. Rio de Janeiro 12:187–202. *4 pl.*

Scholes, Arthur (1951). Fourteen men, the story of the Australian Antarctic Expedition to Heard Island. London front. 5 p. 1. 273 pp. *10 pl.*

Spegazzini, C. (1909). Mycetes Argentinenses. Series IV. An. Mus. Nac. Buenos Aires 19:257–458. *40 fig.* [see p. 279].

Taylor, B. W. (1954). An example of long distance dispersal. Ecology 35:569–572.

Vainio, E. A. (1890). Etude sur la classification naturelle et la morphologie des lichens du Brésil. [Thesis Univ. Helsingfors]. Acta Soc. Fauna Fl. Fenn. 7:1–247; Pars II, 1–256. [see part 2 p. 27].

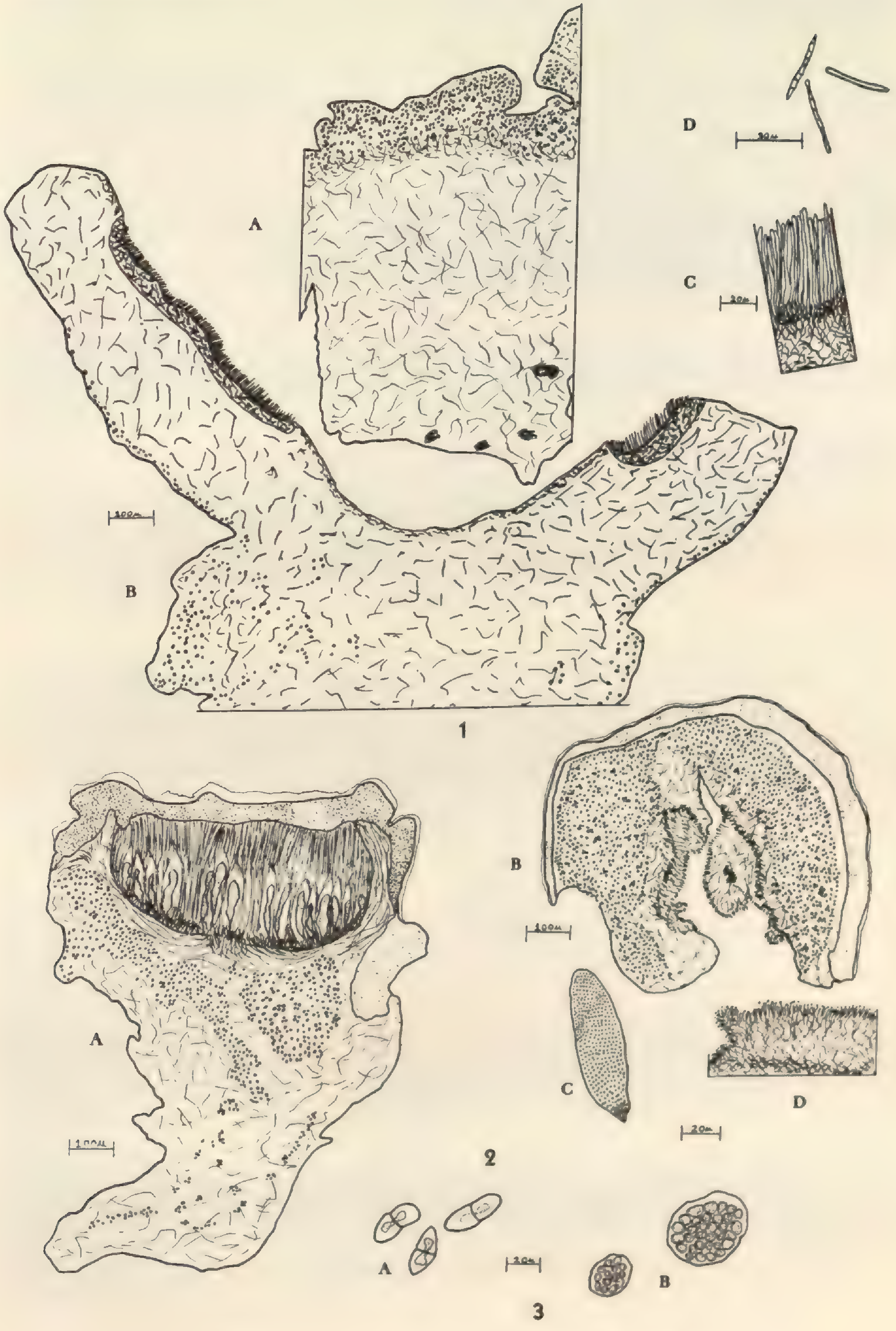
Explanation of Plate

PLATE 15

Fig. 1. *Ephelidium heardensis* Dodge & Rudolph.
- A. Cross-section of thallus.
- B. Cross-section of orthidium.
- C. Conidiophores.
- D. Conidiospores.

Fig. 2. *Acrospora Gwynni* Dodge & Rudolph.
- A. Cross-section of apothecium.
- B. Cross-section of thallus showing spermogonium.
- C. Ascus.
- D. Spermatiophores.

Fig. 3. *Collemopsidium pyrenuloides* Dodge & Rudolph.
- A. Ascospores.
- B. Algal colonies.



DODGE & RUDOLPH—LICHENOLOGICAL NOTES, I–IV

1

2

DODGE & RUDOLPH—LICHENOLOGICAL NOTES, I–IV

PLATE 16

Fig. 1. Heard Island, Laurens Peninsula.

Fig. 2. Heard Island, Coast of Atlas Cove.

(Photographs taken by the Australian National Antarctic Expedition.)

THREE NEW ANNONACEAE FROM PANAMA[1]

ROBERT E. FRIES

ANAXAGOREA **Allenii** R. E. Fr. n. sp.—Arbor circ. 6 m. alta; ramuli novelli brevissime rufo-tomentelli. Foliorum petiolus 10–12 mm. longus, crassus; lamina papyracea, (exsiccata) flavo-viridis, supra glaberrima laevisque, subtus demum glaber et pallidior, oblongo-lanceolata, basi rotundata, apicem versus sensim longeque angustata, 30–35 cm. longa et 8–10 cm. lata; costa supra subplana, subtus valde prominens, teres, rugosus; nervi laterales I. utrinque circ. 15, sub angulo circ. 80° exeuntes, deinde sursum curvati, sicut venulae subtus paulo elevatae. Pedicelli florum breves (3–5 mm. longi), crassi, sicut sepala et petala rufo-tomentelli, juxta calycem bractea vaginaeformi instructi. Sepala ovato-orbicularia, apice rotundata, non recurvata, 7–10 mm. longa. Petala crassa, exteriora oblonga, apicem rotundatum versus haud angustata intus apicem versus carinata, ad 12 mm. longa et 5 mm. lata; petala interiora lanceolata, acutissima, ad mediam partem pilosa et supra medium intus carinata. Stamina linearia, 3 mm. longa; appendix connectivi tenuis, circ. 0, 7 mm. longa, apice rotundato-truncata. (Fructus ignotus).

CANAL ZONE: Quebrada López, alt. 30 m., in flower, Feb. 11, 1940, *P. H. Allen 2143* (Type in Herb. Missouri Bot. Garden).

This species is very like the *Anaxagorea crassipetala* Hemsl., found in Guatemala and Nicaragua, but differs from this especially in its leaves being larger, rounded at the base, and with much-elongated, almost thread-like apices; in its pedicels being short and thick, in its sepals being longer and of rounded oval, not triangular-shape, and its outer petals longer and not tapering toward their apices. it is also similar to *Anaxagorea dolichocarpa* Sprague and Sandwith, from which it differs by sepals rounded at the tips and not retroflexed, short inner petals, shorter stamina, etc.

UNONOPSIS **panamensis** R. E. Fr. n. sp.—Ramuli novelli pilis brevibus ferrugineis erecto-adpressis vestiti. Foliorum petiolus teres vel supra planus, tomentellus, 4–5 mm. longus; lamina chartacea, exsiccata flavo-virens, supra laevis et primo in costa minute hirsuta, demum omnino glabra, subtus in costa hirsuta glabrescens, oblongo-oblanceolata, supra medium latissima, basi breviter acuta, apice abrupte contracta et 1–1.5 cm. longe cuspidata, 15–20 cm. longa et 4–5 cm. lata; costa utrinque elevata; nervi validiores utrinque circ. 15, arcuatim adscendentes et 1–2 mm. a margine conjuncti, tenues et supra elevati; reticulum venularum in foliis adultis haud conspicuum. Inflorescentiae ex axillis foliorum delapsorum evolutae; pedicelli florum crassi, ferrugineo-sericei, breves (7 mm. longi vel ultra?), paulo supra basin articulati. Sepala inter se libera, rotundato-ovata, acutiuscula, circ. 2 mm. longa. Petala rigida, exsiccata nigrescentia, exteriora rotundata et extra ferrugineo-sericea, circ. 7 mm. in diam., interiora minora, secundum nervum medium ferrugineo-tomentosa. Stamina 1.8–2 mm. longa,

[1]Issued June 23, 1955.

apice truncata. Ovaria 1, 5 mm. longa, prismatica et breviter strigosa, stigmate globoso-ovoideo coronata; ovula 3–4, lateralia. (Fructus ignotus).

Panamá: Cerro Campana, trail from Campana to Chica, alt. 600–800 m., with flowers Aug. 10, 1941, *Allen 2647* (Type in Herb. Missouri Bot. Garden).

The material is unfortunately scanty, with no fruits at all. The number and lateral positions of the ovules, however, prove it to be well differentiated from the Central American species *U. Pittieri* Saff. and *Schippii* R.E.Fr. Flowers of the third and last Central American species, *costaricensis* R.E.Fr. (Acta Horti Bergiani 13:105. 1941) are unknown so far, but its fruit structure with one single oblique to horizontal seed favours the view that, structurally, the flower agrees with that of *Pittieri-Schippii,* and accordingly differs from *panamensis. Unonopsis panamensis* also differs from *costaricensis* in having much larger and differently shaped leaves. In my survey of the species of this genus (Acta Horti Bergiani 12:237) *panamensis* should be ranged among the *guatteriodes, obovata,* and allied species, but cannot be joined to any of these.

Guatteria inuncta var. **caudata** R. E. Fr. nov. var.—Differt a typo foliis pro rata angustioribus, basi longe cuneato-angustatis, apice acumine 2–3.5 cm. longo caudiformi acutissimo ornatis, pedicellis florum tenuioribus.

Bocas del Toro, vicinity of Chiriquí Lagoon, Old Bank Island, *von Wedel 2108* (Type in Herb. Missouri Bot. Garden).

THE BOTANICAL CATALOGUES OF AUGUSTE DE ST. HILAIRE

JOHN D. DWYER*

The recent essay of Jenkins[1] serving as an introduction to Auguste de St. Hilaire's *Esquisse de mes voyages au Brésil et Paraguay* focused considerable attention on this French naturalist who collected plants and animals in southeastern Brazil during 1816–1822. Few of the 30,000 plant specimens collected by St. Hilaire[2] have found their way into other botanical institutions from the herbaria of the Muséum National d'Histoire Naturelle in Paris or the Université de Montpellier[3]. This has contributed to the failure of many modern monographers of Brazilian plants to cite St. Hilaire material.

While studying at the Muséum National d'Histoire Naturelle in Paris I came upon the ten handwritten books constituting the catalogues of plants collected by St. Hilaire[4]. It is my hope to demonstrate the importance of these catalogues and also to rectify some errors made in the handling of the St. Hilaire collections.

I wish to express my thanks to Prof. H. Humbert, Directeur Laboratoire de Phanèrogamie, Muséum National d'Histoire Naturelle, Paris, France, for permission to examine and to have microfilmed the catalogues of Auguste de St. Hilaire, as well as to use the facilities of the Herbarium. I owe especial gratitude to Monsieur J. Leandri, Sous-Directeur of the same institution, for his substantial assistance. To Mr. George Swett, Examiner of Questioned Documents, Clayton, Mo., I extend my heartfelt appreciation for his comparison of handwritings found in and related to the catalogues.

ST. HILAIRE IN BRAZIL

St. Hilaire set foot on Brazilian soil at Rio de Janeiro on June 1, 1816. He was destined to be the first French naturalist to penetrate into the interior of southeastern Brazil. Rio de Janeiro, the infant capital of Portuguese Brazil, was from the time of Vellozo in 1780 the hub of botanical activity in South America. Three years before the arrival of St. Hilaire, Georg von Langsdorff, a German, found the capital an ideal center for his botanical work. Two English collectors who botanized in Rio de Janeiro and in São Paulo, Brazil, James Bowie and Alan

[1] Jenkins, A. E., in Chron. Bot. 10¹:5–21. 1946.

[2] *Rapport sur le voyage de M. Auguste de Saint-Hilaire dans le Brésil et les Missions du Paraguay*, lu à l'Académie Royale des Sciences, de Jussieu Rapporteur. 8 pp. Paris, 1823. This rare reprint may be found in the library of the Missouri Botanical Garden, St. Louis, Missouri, as well as the Oliveira Lima Library, Catholic University, Washington, D. C.

[3] In America, for example, there are less than 100 sheets of St. Hilaire material deposited in the Smithsonian Institution (U. S. National Herbarium), Washington, D. C., and less than 40 sheets in the Missouri Botanical Garden, St. Louis, Mo.

[4] I wish to express my gratitude to the National Science Foundation, Washington, D. C., for the grant of money to defray in part the expenses of travelling to the VIIIth Botanical Congress held in Paris in the summer of 1954; at the Muséum d'Histoire Naturelle I had the opportunity to examine the catalogues first hand. I prefer to speak of the books as *catalogues*, despite the fact that it may be more accurate to designate the ten books collectively as a *catalogue*.

* Missouri Botanical Garden and St. Louis University.

Cunningham[5], in their unpublished (Brazilian) diary speak of visiting "Mr. Langsdorff's garden" on January 10, 1815. Four fellow-countrymen of Langsdorff had already penetrated into the interior of southeastern Brazil: Sellow, von Chamisso, Eschscholtz, and Maximilian, Prinz zu Wied-Neuwied. The most illustrious German systematist of this era, von Martius, was soon to arrive (July, 1817). Urban's account of St. Hilaire's five "voyages" informs us that St. Hilaire met two of these botanists, Langsdorff and Sellow[6].

One of the most concise and accurate summaries of the travels and activities of St. Hilaire during his five journeys into the interior from Rio de Janeiro in search of plants, animals, minerals, etc. is to be found in the report of St. Hilaire's travels presented to the French Academy by Baron Cuvier and five other members. This represents the acceptance by the Academy of St. Hilaire's *Aperçu d'un voyage dans l'intérieur du Brésil* of the previous year[7]. I have taken the liberty of translating a section of this "summary" from the French. Wherever possible, the spelling of geographical names has been changed to that of modern usage.

After speaking of St. Hilaire's arrival in Brazil we read:

> In the following December he proceeded northwards, in the province of Minas [Gerais], a territory as vast as France, where he sojourned for 15 months in order to explore its various parts. At first he headed in the direction of Villa Rica, penetrating into old and very extensive forests, covering in turn open country with a different flora, with different birds and insects. There he discovered a "quinquina" unlike the Peruvian kind, but used in the same way, and serving as an indicator of iron. Likewise he observed a grass sticky to the touch, growing luxuriantly in habitats formerly covered with virgin forests. After an illness of a month's duration in Villa do Princípe, he travelled through other forests, situated to the east of this town and studied the survivors of several ancient Indian tribes. He noted in the "district" of Minas Novas a change in the flora, with woods composed of only small shrubs. Further on, other trees of greater stature appeared, called *Catingas*, which are leafless during the dry season. He spent fifteen days on the banks of the Jequitinhonha in the midst of the Botocudos, warlike Indians who live in the forests, naked and without definite dwelling places. From there he turned toward the mighty San-Francisco river, followed along its banks and entered the District of the Diamonds [Diamantina] and visited the areas where he had previously noted their methods of extracting gold from the mountains and rivers. Returning to Villa Rica by a long detour, he again headed for Rio (de) Janeiro arriving in March of 1818, whence he sent to the Muséum d'Histoire Naturelle a shipment of 200 birds, some quadrupeds, 800 species of insects, and two hundred packets of seeds, as well as two botanical papers which have been printed in the publication of the Muséum.
>
> A second voyage of several months duration brought him to the maritime districts, to the north of Rio de Janeiro, as far as the Rio Doce, and yielded just about the same materials as those collected in the woods adjacent to the capital with the exception of those markedly different ones found on the sandy expanses. He visited Cabo Frio, the town of San Salvador de Campos, the entire province of Espírito Santo, the unhealthy banks of the Rio Doce, and having embarked at Villa da Victoria, he returned by sea to Rio de Janeiro, whence he sent a new shipment of animals and of seeds to the Muséum.
>
> His third voyage, the longest and most important, begun in January of 1819, was at first toward the northwest in the eastern section of the province of Minas [Gerais] where he saw a beautiful waterfall at the source of the São Francisco, and the sulphur springs of Araxá whose waters cattle drink unhesitatingly. To arrive at Goiaz he followed a barren plateau

[5] Bowie and Cunningham were to depart from Rio de Janeiro in October of 1816, the former to collect at the Cape of Good Hope, the latter in Australia. Their unpublished Brazilian journal is at the Royal Botanic Gardens, Kew, England.

[6] Urban, I., in Martius' Flora Brasiliensis 1^1:93–98. 1906.

[7] St. Hilaire, Auguste de, in Mém. Mus. d'Hist. Nat. 9:307–380. 1822.

whose opposite sides form the sources of the São Francisco river and the Dos Tocantins both entering the sea from different directions. The vegetation struck him as being little different from that seen on the banks of the São Francisco. The pastures were at times entirely barren, at times covered with small stunted trees. M. de St-Hilaire after having visited Villa Bôa, capital of the province of Goiaz, spent a few days among the Coyapos Indians, then went to the border of Matto Grosso; from here he took a southeastern route to São-Paul. He arrived there in December 1819, after a long and arduous journey marked by great heat and dryness, and here he deposited his various collections, packed with care, to permit him to continue southwards.

At first he skirted the western side of the vast chain of mountains which separate the interior of the country from the seashore, and saw in succession the following villages: Sorocaba, Itu, Pôrto Feliz and their environs; he noted the boundaries of the most important colonial industries. Then he entered Campos Gerais, such delightful country because of its diversified countryside. He made a goodly collection of plants which indicated a more temperate climate. There he observed the erroneously named *herbe du Paraguay;* this he correctly identified as a tree of the genus *Ilex*. He also identified the local *quinquina* which is in reality a *Solanum*. Crossing over a chain of mountains at a difficult spot called Serra de Paranagoa, he found himself at the sea coast at a much lower altitude and hotter than the interior plateau whose crops approximate more those of the tropics even as far south as 27° latitude. He was able to visit the islands of St. Francis and of St. Catherine and their whaling-posts. Here the ground beyond is a sandy and dry stretch enlivened only by the presence of a prodigious number of aquatic birds.

The province of Rio Grande, which he soon entered, is very fertile, with a more vigorous population. He observed that the culture of sugar-cane stops at about 30° while cotton-growing extends to 31°, palms to 34°, just at noted in New-Holland [Australia]. He spent the winter, already severe in these areas, at Pôrto Alegre and at Rio Grande, departing in October 1820, that is in the springtime of this country. The plants which flourish at this time belong to the same genera as those constituting the spring flora in Europe, such as the *carex* [sedges], *anemones, centunculus* [chaffweeds], *arenaria,* etc. He recognized, too, the influence of climate on vegetation: thus, in the coldest season, the trees retained their foliage, up to a degree north of Pôrto Alegre; a third lose their leaves at Rio Grande, and at two degrees further south scarcely a tenth have retained their leaves.

M. de St. Hilaire then entered the Spanish possessions, passed through several towns and beautiful estates along the banks of the Rio de la Plata, arriving at Montevideo where the vegetation appeared to him to be so closely related to that of Europe that he scarcely found fifteen plants which could not have been assigned to European families. He also noted around certain towns that several of our own plants were well acclimated; he called attention to this especially near Montevideo, where vast waste-lands were covered with our *cardon* [thistle] growing wild and used solely as fuel. Proceeding then in the direction of the Rio Negro, a river rushing headlong into Uruguay, he found beyond a country considerably less populated and with customs agreeing with the descriptions of Azzara. His journey became more difficult between Belem and the province of the Missions, and he spent thirteen days in an uninhabited desert, populated only by *autruches* [rheas], *cerfs* [deer], and *jaguars*, against which he had to defend his own life, and especially that of his horses; unfortunately he could not save all of the horses. It was in this district that curious accidents befell him and his two companions after having eaten several spoonfuls of a honey made by a species of wasp. He visited the seven small villages which are all that remain of thirty which constituted in time past the ancient missions of Paraguay. Observing these carefully, he could naught but groan at finding only ruins and the sight of such misery in a fertile land whose former splendor our writers have not exaggerated. Then re-entering Brazil proper and traveling in the rainy season, he frequently ran the risk of losing his notes and collections; he returned at the end of a year by a detour to Pôrto Alegre, embarked on Lake Patos for Rio Grande; returned by sea to Rio Janeiro, where he arrived toward the end of 1821, after an absence of nearly three years.

St. Hilaire has elaborated on his travels in his own *Esquisse* (loc. cit.) and his *Voyages*. These are in need of careful study by contemporary scholars.

The recent remarks of the Brazilian P. R. Reitz (Anais Botanicos do Herb. Barbosa Rodrigues 1:86. 1949) on St. Hilaire reflect the warm affection of the Brazilians for the French naturalist. I have taken the liberty of translating freely the same from the Portuguese:

> He had a kind heart, adapting himself to the environment in which he lived and likewise to the uneducated people with whom he often traveled, treating with the manners of a gentleman those who helped him, censuring amiably those who treated him badly.
>
> He described objectively the customs of our lands. St. Hilaire stands in marked contrast to those pseudo-investigators who, as tourists, describe our country as a grand carnival from the seats of gambling halls or even from the summit of Corcovado[8] where they sit to write their observations, their memoirs of the people, of the Brazilian way of life and customs. Only a St. Hilaire, a Martius or a Bonpland who came to Brazil with great sacrifice, who traveled through inhospitable areas, could sense the pulse of the Brazilian heart not only in the cities but in the back country and small villages, could see in their habitats great diversity of plants, animals, and minerals. Only these or others of their calibre could describe, in the role of investigators, our natural riches and our people.

There is an excellent map of the itinerary of St. Hilaire's five "voyages", prepared by J. Santos for *Chronica Botanica* (loc. cit. p. 12), from St. Hilaire's original in the back of his *Voyage à Rio Grande do Sul.* A large map found in the first volume of *Martius' Flora Brasiliensis* labelled "Itinera Botanicum" with inked-in itineraries of the majority of the principal botanists who collected in Brazil from 1780 to 1852 is unfortunately inaccurate, at least with respect to St. Hilaire. For example, the delineator indicates that St. Hilaire collected as far north on the eastern coast of Brazil as Villa de Porto Seguro (Bahia); this is almost 225 miles north of the Rio Doce, the most northeastern limits of St. Hilaire's collections.

THE CATALOGUES OF ST. HILAIRE

The catalogues are made up of separate books in St. Hilaire's own handwriting. Approximately 8900 collections are entered in the 1575 pages[9]. My count from the catalogues stands in marked contrast to Urban's statement (*Martius' Flora Brasiliensis* 1^1:92–98. 1906) of the number deposited in three herbaria, that: "Collectio princeps (cr. 7600 numeri) in herbario musei historiae naturalis Parisiensis. Dupla in Montpellier, parca in museo Berolinensi". Urban's estimate may have been the result of adding up the collection numbers in the catalogues *without considering that often single collection numbers were subdivided one to several times,* or from St. Hilaire's own statement (*Esquisse*, p. 61) that: "Le nombre des plantes que j'ai recueillies s'élève à environ sept mille . . . .". In the *catalogues* there are approximately 835 collection numbers which are subdivided *a la "bis", "ter", "4"*, etc. In one instance (in series C_2) the collection number *2791* is subdivided thirteen times and applied to eleven different families of angiosperms. The failure on the part of monographers or copyists to add "bis", "ter", etc. to a specific collection number has caused considerable confusion in the citing of specimens.

Following each collection number is (usually) the specific plant family (written in French) to which the collection belongs. Occasionally only the generic name is given. For approximately 550 collection numbers St. Hilaire fails to supply any taxa although usually one finds an "analysis" or a few words. In more than one

[8] A high peak overlooking Rio de Janeiro easily reached in our times by street-car.

[9] In a letter recently received, M. Leandri writes: "Our catalogue of entries bears actually 7692 gatherings [collections] from St. Hilaire; maybe the others have been lost or kept by A. de Jussieu and Cambessedes (and others)."

third of the entries a detailed description ("analysis") of the plant is given in French. In some families, for example in the Orchidaceae, these descriptions may take up three full pages. St. Hilaire paid particular attention to listing the common names of the plants as well as their economic uses. The place of collection is usually found at the end of the "analysis".[10] The "analyses" are models of precision and critical observation. St. Hilaire himself states (*Esquisse,* p. 61) ". . . . . je les ai toutes analysées sur les lieux-mêmes, et me suis principalement attaché à la dissection des parties dont la connoissance répand le plus de lumières sur les rapports naturels".

Dreuzy, a great-nephew of St. Hilaire, in an appendix to the *Voyage à Rio Grande do Sul,* refers to the difficulties encountered by Saint Hilaire in preparing his "journal botanique", the name by which Dreuzy apparently designates St. Hilaire's diary and his catalogues collectively:

> Nous donnons ci-dessous quelques extraits de ce volumineux journal pour faire comprende au lecteur quel travail s'imposait l'auteur au soir de chacune de ses fatigantes journées de voyage, assis sur ses malles sous un rancho, éclairé par la lueur tremblante d'une chandelle fumeuse, dévoré par les moustiques qu' attirait la lumière.

Dreuzy then supplies two samples of St. Hilaire's "analyses" from catalogues C^2, Section 2, one collection number *2682,* and the other *2787*^{bis}. To my knowledge these are the only "analyses" which have been published *in toto.* In fact, I have found no reference of any length in the literature concerning St. Hilaire's catalogues. We may use Dreuzy's sample *2682* as typical of an "analysis" of St. Hilaire:[11]

> ESTANCIA DE SANTO-REI, 1er mars, n° 2682. Graminée. Sur chaque dent de l'epi sont 2 fleurs, l'une sessile, l'autre pédiculée. Épillets sessiles, 1 fl. herm., lancéolés, sous-falciformes, glumes 2-valves, à valves ext. hérisée, lancéolée, tantôt simplement aiguë, tantôt courtement 1 ou 2 arrètées à valv. int. un peu plus courte que l'autre lancéolée-aiguë, pubescente. Glumelles 2-valv., à valv. membraneuses sous-violettes, sous-pubescentes presque égales, obtusiuscules, 2 paléoles tronquées; 3 et 2 styles sétacés, 2 stig., complets, continus, plumeux, ovaire glabre ovoïde. *Epillets pédicelles* mâles. Glumes 2 valv. à valve ext. pubescente, lancéolée-linéaire-aiguë, plane, à valve int. lancéolée-aiguë, presque égale à l'autre pubescente carènée, 2 paléoles tronquées. 2 ét. glumelles 2 valv. à valves lancéolèes, linèaires, aiguës, presque égales, ciliées, membraneuses, un peu violettes. Toute la plante répand une forte odeur de citron. Nom. vulg. *capim limao.*

Unfortunately, St. Hilaire made no great effort to list binomials in the catalogues. In the more than 8900 collection numbers there are approximately 160 binomials, the majority in St. Hilaire's handwriting and a few in Spach's. Most of

---

[10] The catalogues do not list as many specific localities as does Urban in his elaborate list of the itineraries of St. Hilaire in *Martius' Flora Brasiliensis* (loc. cit.). Here more than 800 localities are given arranged in proper sequence as well as according to the years of St. Hilaire's five "voyages". It is probable that Urban gleaned this detailed itinerary from St. Hilaire's own published reports of his trips.

[11] Unfortunately, in *2682* Dreuzy terminates this "analysis" of a Graminée with the binomial *Echites guaranitica* Aug. de S.-H. This binomial, despite the fact that it appears in the catalogues to be written into this "analysis" at the upper right-hand corner, obviously refers to collection number above, *2681* (Apocynacée). To make matters worse, the second "sample" analysis is labelled "*Composée 2787*^{bis}." From the catalogues the collection number is simply 2787.

the binomials are addenda to the "analyses"; those written by St. Hilaire belong as a rule to families on which he published extensively: e. g., Violaceae (including certain genera now assigned to the Ochnaceae), Droseraceae, etc. For some reason "analyses" of certain families, e. g., Malvaceae, Malpighiaceae, etc. are often cross-hatched in ink. In the case of the Rutaceae the numbers of the family were designated by a scrawled name which looks like "Oranger" (pl. 17, under *2791*[12]).

Figures 1 and 2 show the number of collections made in specific families (with the exception of the ferns) according to the catalogues of St. Hilaire. Figure 1 lists the families represented by more than 50 collection numbers; fig. 2 lists those represented by less than 50 and more than 20 collection numbers. The family Leguminosae is considered *in sensu lato* to include the Mimosaceae and Caesalpiniaceae. The Ochnaceae includes certain genera which St. Hilaire related to the Violaceae, e. g., *Sauvagesia, Lavradia.* To avoid confusion I have combined the Liliaceae with the Amaryllidaceae.

NUMERICAL SEQUENCES OF ST. HILAIRE COLLECTIONS

In preparing a collection of plants for herbarium deposit the most convenient sequence of collection numbers is a continuous linear one which is correlated with the date of collection and the itinerary of the collector. In examining the more than 8900 collections of St. Hilaire we find the following numerical sequences[12] in the ten books:

Book 1—	1– 758	Book 6—	86– 96
Book 2—	464– 650 1B– 132B	Book 7—	1– 60 (not in St. Hilaire's handwriting) 1–1175
Book 3—	1– 63, 103–2085	Book 8—	1176–1899, 2000–2797 1– 219
Book 4—	1– 112	Book 9—	692– 709, 1858–1869, 2004–2120
Book 5—	2101–2489 1– 408	Book 10—	1– 818

Despite the patch-work pattern of these sequences of numbers definite correlations exist between sets of numbers and the itineraries of St. Hilaire's five voyages. It is not impossible that St. Hilaire prepared the catalogues *following* his return to Paris in 1822. I have seen certain individual "analyses" attached to herbarium sheets in the Paris Herbarium, e. g. to one of several of St. Hilaire's unnumbered collections of *Lavradia capillaris* (Ochnaceae). It may be that the "analyses" were written on separate sheets of paper in the field, inserted separately with the unmounted specimens and then removed in Paris to be gathered together and recopied into a catalogue. The mounting of his 30,000 specimens in Paris may have resulted in some confusion in the re-organization of the "analyses" in the catalogues. Occasionally, one finds the date 1822 at the end of an analysis, suggesting that an addendum was made to the original more-abbreviated "analysis". The "analyses", too, are generally written in a neat (but often difficult to decipher)

[12]In a given run of a number in the catalogues it is not uncommon to find occasional numbers missing or out of place. For the sake of brevity I am not specifying these, although the absentees have been taken into account in computing the sum-total of collection in the catalogues.

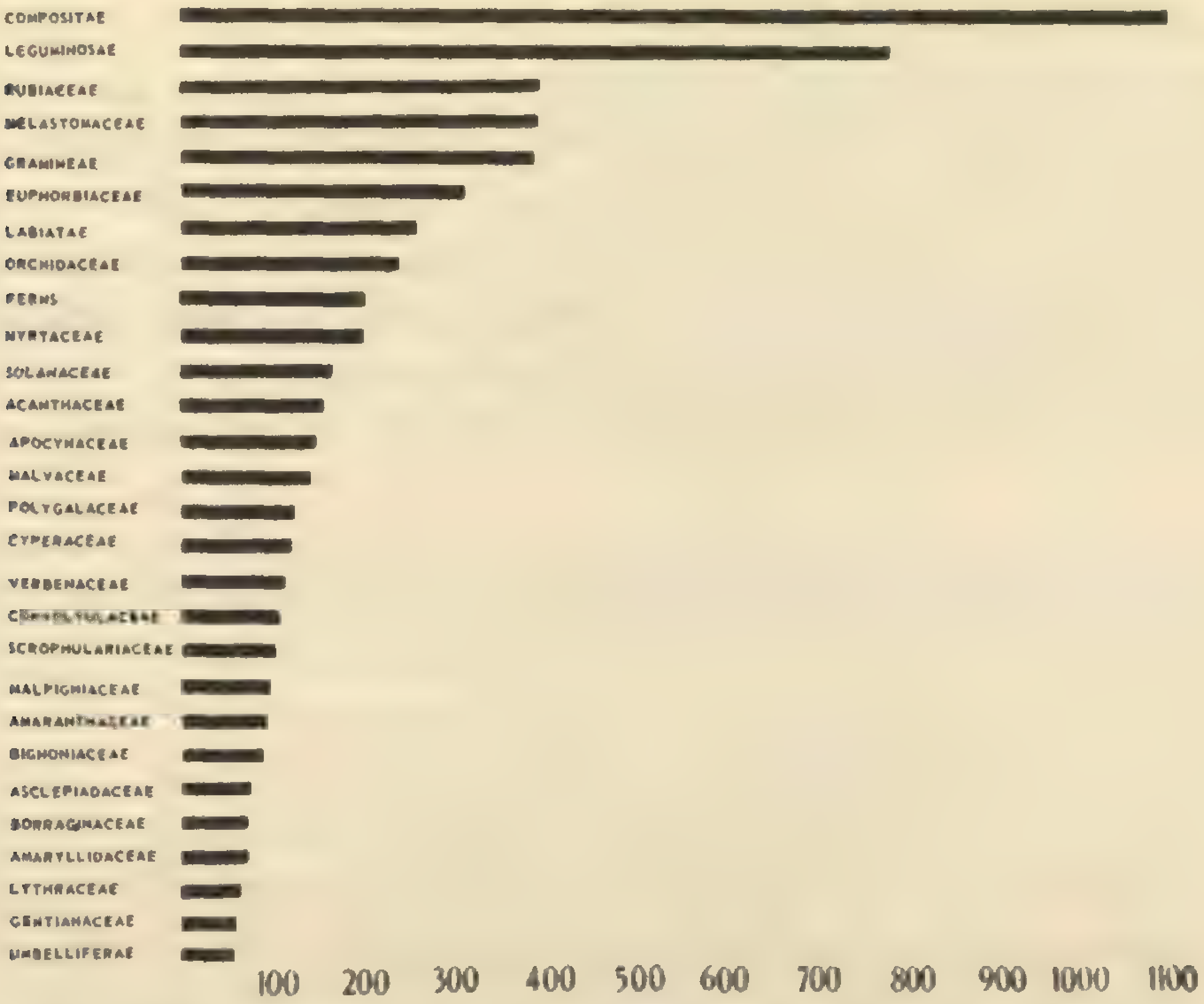


Fig. 1. Approximate numbers of collections listed under specific families of Angiospermae (except for Ferns) in the botanical catalogues of Aug. de St. Hilaire. Only those families with collections in excess of 50 are shown.

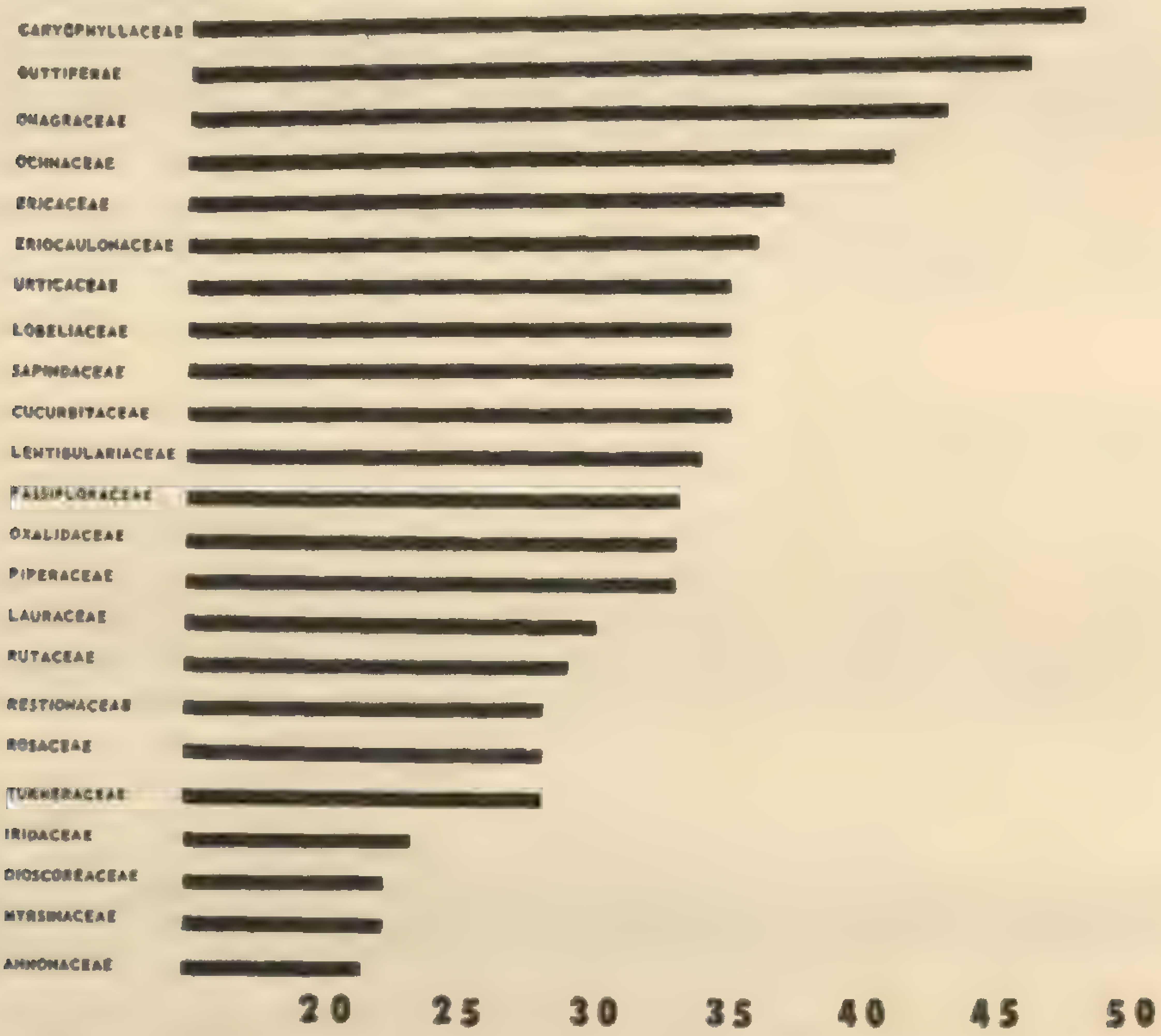


Fig. 2. Approximate numbers of collections listed under specific families of Angiospermae in the botanical catalogues of Aug. de St. Hilaire. Only those families with at least 20 and not more than 49 collections are shown.

hand. Perhaps legibility is too much to expect of a scientist working in the evening after an exhaustive day in the field.

In Book 5 Weddell writes that certain notes for collection numbers 2085–2101 were not sent to the Museum for insertion. Several points argue against this possibility, however. In the first place, it is more logical, if not more safe, to insert the "analyses" initially into a field book; again we note, especially in the early books, that St. Hilaire often fails to complete an "analysis" before beginning the next collection number but occasionally completes the "analysis" on another page and consequent to a different collection number. It is difficult to believe that he would do this if he were preparing the catalogues in Paris. The fact that volume 6 has only 11 collection numbers sandwiched in with what is obviously a segment of his diary written in the field is another substantial point of evidence.

St. Hilaire and his contemporaries used these numbers in the catalogues of collections and for herbarium sheets, and not for purposes of citation in the literature. St. Hilaire and his co-workers in the *Flora Brasiliae Meridionalis*, Jacques Cambessèdes and Adrien de Jussieu, never cite collections by number. No doubt, they did not consider individual collections to be as important as do our botanists of today who adhere to the principles of the type concept.

Obviously, if a collection of St. Hilaire had been cited, e.g.,No. 26, the reader would wonder to which sequence to assign it unless the locality were given. Weddell[13], no doubt stimulated by the pioneer efforts of certain authors in *Martius' Flora Brasiliensis* in citing collectors and collection numbers, attempted (probably in the 1860's) to organize the catalogues in a manner more suitable for citation and for labelling of specimens. Unfortunately, Weddell did not publish his "Key" to the catalogues[14]. The facts that Spach, who was curator of the herbarium at the Muséum d'Histoire Naturelle, employed Weddell's system on printed labels and that certain monographers have used the Weddellian system give some status to the key. We shall discuss the popularity of Weddell's key in following paragraphs.

---

[13] H. A. Weddell (1819–1877), an "aide-naturaliste" to Adrien de Jussieu, collected extensively in Brazil; in addition he was a distinguished taxonomist at the herbarium of the Muséum d'Histoire Naturelle, Paris.

[14] In recent years some members of the staff of the Muséum d'Histoire Naturelle, Paris, prepared a typewritten copy of Weddell's key. Weddell's handwritten key may be found scattered in the front of the catalogues of St. Hilaire (see pl. 18). An accurate handwritten summary (not figured here) of the sequences of numbers (accompanied by broad geographical data) of St. Hilaire's botanical collections occurs in the initial two pages of Book 8 of the catalogues. Mr. Swett, Examiner of Questioned Documents, Clayton, Missouri, expresses the probability that this was prepared by a person (or persons) other than St. Hilaire, Weddell, or the author or authors of the page shown in pl. 19. It was obviously not prepared by Spach. I have elected to credit Weddell with the establishment of the key to St. Hilaire's collections. That Weddell inserted notes in numerical sequences and geography in many of the books of St. Hilaire seems certain. M. Leandri of the Laboratoire de Phanerogamie, Muséum D'Histoire Naturelle, Paris, writes me that the typewritten key was "copied from notes in the books [St. Hilaire's catalogues] partly of the handwriting of Weddell". While Weddell may have based his insertions on the well-organized summary found in book 8, it seems safer to suppose that the latter was prepared from his notes.

WEDDELL'S KEY TO THE CATALOGUES OF ST. HILAIRE

Weddell divided the *books*[15] constituting St. Hilaire's catalogues into four series: A (books 1, 2, 3, and 4); B (books 5 and 6); C (books 7, 8, and 9); and D (book 10). Series A is divided into two volumes, B, into two volumes, C, into three volumes, and D consists of one volume. The following revised outline is based on a recent typewritten summary of Weddell's key found in the herbarium at Paris:

SERIES A (TWO VOLUMES)

A^1, comprising numbers 1–758.—

Plants collected during the year 1816, some in the vicinity of Rio de Janeiro (1–469 and 651–758), others in the vicinity of Uba, on the Rio Paranhyba about 25 leagues from Rio de Janeiro, and in the same province (470–650).

A^2, in two sections.—

Section 1, comprising numbers 464–650, which are duplications of the same numbers in Volume A^1.

Section 2, comprising numbers 1^B–130^B (or 132^B). Plants from the environs of Rio de Janeiro collected in 1818.

SERIES B (TWO VOLUMES)

B^1, comprising numbers 1–2085 (December 1816 to March 1818).—

Plants collected in the province of Minas Gerais, with the exception of 1–25, which are from the province of Rio de Janeiro.

B^2, in two sections.—

Section 1, comprising the numbers 2101bis to 2493; these follow in order the series of plants of Minas Gerais which constitutes the three previous volumes.

Section 2, comprising the numbers 1–408. Plants collected during a "voyage" on the seacoast of Brazil, from Rio de Janeiro to the Rio Doce in the provinces of Rio de Janeiro and Espiríto Santo, from August to November, 1818.

SERIES C (THREE VOLUMES)

C^1, comprising numbers 1–1175.—

Plants collected in the following districts:

1– 10—Province of Rio de Janeiro. 1819.
11– 625—Province of Minas Gerais. 1819.
926– 985—Province of Minas Gerais. 1819.
626– 920—Province of Goiaz. Sept. 1819 to May, 1820.
986–1175—Province of São Paulo. Sept. 1819 to May, 1820.

C^2, divided into two sections.—

Section 1, comprising numbers 1176–2797. Plants collected in the following regions:

1176–1704—Province of São Paulo. May, 1820.
1705–1806—Province of Sta. Catarina. May to June, 1820.
1807–1874—Province of Rio Grande do Sul. 1820.
2569–2797—Province of Rio Grande do Sul. 1820.
1875–1899, 2000–2260 }—From San Pedro de Rio Grande to Montevideo. 1820.
2261–2568—From Montevideo to the Brazilian frontier on the banks of the Uruguay. 1820.

Section 2, comprising the numbers 1–219c.
Plants collected in the environs of Rio de Janeiro, in July, 1821.

C^3.—

Comprising three small series of numbers (692–709, 1858–1870, and 2004–2020) to be intercalated in the large series of numbers contained in volumes C^1 and C^2.

[15] Weddell referred to these as *volumes*.

SERIES D (ONE VOLUME)

D, comprising the numbers 1–818.—

Plants collected in 1821 and 1822 during the last voyage of St. Hilaire, in the following places:

1– 30—Province of Rio de Janeiro.
31– 587—Province of Minas Gerais.
588– 818—Province of São Paulo.

Certain elements of confusion exist in the interpretation of these numbers. In Book 2 the numbers 464–650 are simply duplicates ("double emploi") of the same numbers in the 1–758 sequence of Book 1. The numbers 1–112 in Book 4 are duplicates of those found in Book 3 except for 64–102 which are missing in Book 3. The numbers 86–96 in Book 6 (if one should refer to this as Book 6 inasmuch as it is apparently one of St. Hilaire's diaries) belong to the sequence of numbers in Book 5 from which they have been omitted. In Book 7 the initial sequence of numbers 1–60 are not in St. Hilaire's handwriting[16]. In Book 8 numbers 1900–1999 are missing, apparently due to carelessness.

Weddell (?) used paper labels for all the specimens of the collections except numbers 1–758 in catalogue A^1 (Rio de Janeiro), 1–25 in B^1 (Rio de Janeiro), and 25–2085 in B^1 (Minas Gerais), for which parchment labels were used. All paper labels, except for numbers 2101bis to 2469 of B^2 section 1 (Minas Gerais), and 2470 to 2493 B^2 section 1 (Rio de Janeiro) bear, or should bear, symbols. This is summarized as follows:

TABLE I

Labels	Numbers	Catalogues	Localities
Paper δ	1– 240	B^2 Sect. 2	Rio de Janeiro
	241– 408	B^2 Sect. 2	Espiritu Santo
Paper B	1– 130	A^2 Sect. 2	Rio de Janeiro
Paper C	1– 219	C^2 Sect. 2	Rio de Janeiro
Paper D	1– 30	D	Rio de Janeiro
	31– 587	D	Minas Gerais
	588– 818	D	São Paulo
Paper O	1– 10	C^1	Rio de Janeiro
	11– 625	C^1	Minas Gerais
	626– 691	C^1	Goiaz
	692– 709	C^3	Goiaz
	710– 920	C^1	Goiaz
	926– 985	C^1	Minas Gerais
	986–1175	C^1	São Paulo
	1176–1704	C^2 Sect. 2	São Paulo
	1705–1763	C^2	Sta. Catarina
	1764–1775	C^2	São Paulo
	1776–1806	C^2	Sta. Catarina
	1807–1857	C^2	Rio Grande do Sul
	1858–1870	C^3	Rio Grande do Sul
	1871–1874	C^2	Rio Grande do Sul
	1875–2003	C^2	Banda Oriental del Uruguay
	2004–2020	C^3	Banda Oriental
	2021–2568	C^2	Banda Oriental
	2569–2797	C^2	Rio Grande do Sul

[16]These 60 numbers have neither families nor "analyses" appended, although the localities of the collections are given. Some of the localities (e. g., Barbacena, Rio Ouro Branco) suggest the beginning of St. Hilaire's second voyage to Minas Gerais in 1816. On this voyage he was accompanied by I. Gomes and G. H. de Langsdorff. Perhaps these are collections of one or both of these men.

THE ROLE OF THE CATALOGUES OF ST. HILAIRE IN TAXONOMIC MONOGRAPHS

Although only a few botanists such as Weddell, Spach, Dreuzy, etc., are known to have consulted the catalogues of St. Hilaire, the various check-marks and binomials inserted suggest that they may have been studied by others.

Prior to an arbitrary date of 1860 monographers in citing St. Hilaire collections, in imitation of St. Hilaire, Cambessèdes, and de Jussieu failed (usually) to supply collection numbers but gave clear-cut geographical data. Later monographers often used St. Hilaire collection numbers, and, almost without exception, they furnished only a fraction of collections as listed in the catalogues. Mueller, for example, in his classic work on the Apocynaceae (Mart. Fl. Bras. 6^1:1–195. 1860) gave collection numbers for only 23 of the 56 collections of St. Hilaire which he cites. These 56 collections represent about one-third of this family as listed in St. Hilaire's catalogues, all of which have specific collection numbers. In general, in *Martius' Flora Brasiliensis* it is the exception to find collection numbers when St. Hilaire material is cited; collecton numbers are missing, for example, in Radlkofer's monograph of the Sapindaceae (1895), Bennett's work on the Polygalaceae (1874), Koehne's work on the Lythraceae (1887), etc. (see Table II).

No doubt much of the confusion and inconsistency encountered in the citation of St. Hilaire's collections, especially by the 19th century monographers, arise from several circumstances: (a) localization of the bulk of the St. Hilaire collections in the Paris herbarium; (b) the fact that the duplicate collections often have labels bearing only a binomial and the geographical data (often undecipherable)[17]; (c) the lack of interest in collection numbers by the contemporaries of St. Hilaire; (d) awkward and overlapping sequences of numbers prior to Weddell's groupings; (f) the subsequent failure to apply the Weddellian system to many of St. Hilaire's collections.

Table II, based on an examination of twenty monographs (1832 to the present) which include St. Hilaire's collections, reveals many important points[18]. In the Anacardiaceae (D.C. Monograph. Phanerogam. 4. 1883) Engler cites eleven collection numbers of St. Hilaire, none of which has catalogue numbers; in attempting to check them against the catalogues it appears from the blank spaces in the latter that St. Hilaire may not have been certain of the characters of the Anacardiaceae and thus never entered the family name. In Cogniaux's Cucurbitaceae (D.C. Monograph. Phanerogam. 3. 1881) the number of St. Hilaire's collections cited exceeds the total number estimated to be entered in the catalogues under this family. This disparity is a reflection of the number of blanks left by

---

[17] Of the 59 sheets of St. Hilaire reported by Dr. Lyman B. Smith, of the Smithsonian Institute (Washington, D. C.), to be in that herbarium only 34 bear collection numbers; of these only two have the Weddellian series appended to the number. I have been unable to locate ten of the numbered specimens with certainty in the catalogues.

[18] When the collection numbers are not listed in a monograph the author may be including more than one collection (of St. Hilaire) for the species in question without making the same clear. This makes an accurate statistical analysis of the number of collection cited impossible.

TABLE II

Specific Monograph	Date	Numb. of St. Hilaire collections cited	Numb. of St. Hilaire collections without coll. numbers	Numb. of St. Hilaire's collections with coll. numbers	Numb. of St. Hilaire collections with coll. numbs. and Weddell's series	Numb. of St. Hilaire collection numbers matching those in cat.	Numb. of collection numbers in St. Hilaire's catalogues
Malpighiaceae A. de Jussieu	1832	64	64	0	0	?	97
Melastomaceae Naudin	1849–1852	51	51	0	0	?	378
Apocynaceae Mueller	1860	58	35	23	0	16	147
Polygalaceae Bennett	1874	30	30	0	0	?	122
Erythroxylaceae Peyritsch	1878	8	8	0	0	?	0
Alismaceae Micheli	1881	7	0	7	6	4	6
Commelinaceae Clarke	1881	11	0	11	0	6	18
Cucurbitaceae Cogniaux	1881	36	0	36	35	31	35
Turneraceae Urban	1883	15	1	14	9	10	28
Anacardiaceae Engler	1883	11	0	11	0	0	0
Lythraceae Koehne	1887	24	24	0	0	?	62
Rubiaceae Tribes VII–XIX Schumann	1889–1889	8	7	1	0	1	386
Guttiferae Vesque	1893	4	0	4	1	4	46
Sapindaceae *(Serjania)* Radlkofer	1896	19	19	0	0	?	35
Bromeliaceae Mez	1896	19	0	19	10	7?	14
Bignoniaceae Bureau	1897	2	1	1	0	1	91
Ochnaceae (Ouratées-Orthospermées) Van Tieghem	1902	7	1	6	0	2	41
Passifloraceae Killip	1938	17	0	17	0	11	22
Vochysiaceae (*Salvertia* & *Vochysia*) Stafleu	1948	8	1	7	4	4	15
Labiatae *(Hyptis)* Epling	1949	100	8	92	2	79	244
		497	250	249	67	176	1878

St. Hilaire after collection numbers in the catalogues, some of which are undoubtedly of the Cucurbitaceae.

In Naudin's monograph of the Melastomaceae[19], we find very few of St. Hilaire's collections cited despite the fact that Naudin must have been well acquainted with them[20]. What is even more remarkable is the complete absence of St. Hilaire material in the "second half" of the monograph (i. e., vol. 16, after p. 87. 1851), even though such common Brazilian genera as *Clidemia, Miconia,* etc. are included[21]. In the several sample monographs from *Martius' Flora Brasiliensis* we note that few collections of St. Hilaire are cited as compared with the total number of collections of the specific families estimated to be in the catalogues.

Killip, in his recent treatment of the Passifloraceae (Field Mus. Nat. Hist. Bot. 19:1–613. 1938), cites six numbers which do not check with the corresponding ones in the catalogues. Of these, three (717, 751, and 970) were probably erroneously copied from labels bearing the numbers, 719, 753, and 976 respectively, all of which are entered in the catalogues under Passifloraceae; a fig. 9 may be easily mistaken for a 7, a 1 for a 3, etc.

Epling, in his monograph of *Hyptis* (Rev. Mus. de La Plata, n. s. Secc. Bot. 30:153–497. 1949) cites more St. Hilaire material than any contemporary monographer[22]. Unfortunately, only two of the hundred collections cited bear collection numbers with Weddell's series added. This suggests, of course, that the Weddellian system has not been applied in any great degree to the labelling of specimens. Despite the quantity of St. Hilaire material cited by Epling, approximately 65 collection numbers of *Hyptis* were not included in his work. In checking this genus in the Paris Herbarium 13 of the 92 collection numbers (St. Hilaire) cited by Epling, were not located; but eight of these thirteen can be located readily when "bis", "ter", etc. are appended. (Some copyist of course may have failed to insert "bis", "ter", etc. on the labels.) Of the remaining numbers, probably 578 was misread for 518, and 1155 for 1133.

In those monographs using the Weddellian system the collection numbers are usually matched with ease in the proper volume in the catalogue.

---

[19] Ann. Sci. Nat. Bot. Ser. III, 12:196–284. 1849; 13:25–39, 126–159, 273–303, 347–362. 1850; 14:53–76, 118–165. 1850; 15:43–79, 276–345. 1851; 16:83–246. 1851; 17:305–382. 1852; 18:85–154, 258–294. 1852.

[20] St. Hilaire and Naudin were co-authors of a paper entitled "Revue de la Flore du Brésil Meridionale" which appeared in three sections (Ann. Sci. Nat. Bot. Ser. II, 18:24–54, 209–213. 1842). In addition they were co-authors of a new genus, *Augustinea,* of the Melastomaceae (Ann. Sci. Nat. Bot. Ser. III, 2:145. 1844).

[21] I hope to discuss in another paper the stormy history of the Melastomaceae collected by St. Hilaire.

[22] *Hyptis* is one of the few cases where St. Hilaire wrote a genus name with fair consistency into his catalogues in his "analyses" instead of the family name "Labiée". However, in checking Epling's monograph against the catalogues, it is obvious that St. Hilaire did on occasion use the taxon of family in place of *Hyptis.*

A PARTIAL LIST OF THE GENERA COLLECTED BY ST. HILAIRE

In the herbarium of the Muséum d'Histoire Naturelle, Paris, there exists an unpublished list of about 2000 entries of St. Hilaire's collection numbers; these are arranged according to genera (occasionally binomials are listed) and cover eighteen families or tribes. The author of this list is unknown[23]. Fortunately, the collection numbers of St. Hilaire are entered according to the Weddellian system. The presence of geographical data increases its value considerably (cf. pl. 19).

In the list the entries from numbers 1 to 364 are of the Graminée only, divided according to 13 tribes. Among the Dicotyledoneae we find the following families and tribes listed in the order given (entry numbers 1–1589):

Chloranthaceae	(entries 1–2)	Nyctagineae	(entries 150–182bis)
Piperaceae	(entries 3–44)	Chenopodeae	(entries 183–192)
Celtideae	(entries 45–53)	Amarantaceae	(entries 193–307)
Moreae	(entries 54–85)	Aristolochieae	(entries 308–322bis)
Artocarpiées	(entries 85bis–95)	Proteaceae	(entries 323–328)
Urticacées	(entries 96–100)	Monimieae	(entries 329–337)
Salicineae	(entries 101–103)	Laurinées	(entries 338–390bis)
Lacistemeae	(entries 103bis–103^{5})	Compositae	(entries 391–1572)
Polygoneae	(entries 104–149)	Campanulacées	(entries 1573–1589)

It is obvious that such a list may be of great value to specialists of the above groups working on material from southeastern Brazil. As an example of its usefulness, I was able to ascertain in the model analysis (cf. p. 157) that *Elionurus* is the genus of the grass family described by St. Hilaire.

SUMMARY

Monographers have used only sporadically the Weddellian system in checking the collection numbers of St. Hilaire's material with the specific catalogue series and section, probably due to the absence of these numbers from the majority of the labels of the specimens. The Weddellian system answers the problem of the possible overlapping of collection numbers, and monographers should be encouraged to adopt it. Being aware of the existence of the catalogues of St. Hilaire, they are now able to check collection numbers against St. Hilaire's "analyses"[24]. The catalogues themselves represent an original source of reference for the 8900 collections of Aug. St. Hilaire in southeastern Brazil.

The discovery of a list (author unknown) of some of the genera collected by St. Hilaire, with some 2000 collection numbers entered according to the Weddellian system, should be of great assistance to monographers.

---

[23] There are 17 collection numbers of St. Hilaire and accompanying data at the end of the list which are obviously in Spach's handwriting. This permits one to give the date of the list as some time prior to 1879, the year of Spach's death. Mr. George Swett, from a comparison of one sheet of the above list (pl. 19, a photo from microfilm) with photographs of the writings of St. Hilaire and Weddell (c.f. pls. 17 and 18) expressed the opinion neither prepared the list; he qualifies this, however, by stating that "no opinion is held as to whether the writers (St. Hilaire and Weddell) executed the word *Andropogoneae* in the above sample sheet."

[24] The author, through the Missouri Botanical Garden, will be happy to supply sets of collection numbers of St. Hilaire for specific families to specialists.

APPENDIX

Through a letter received during the proofing of this paper I learned that the Bibliothèque Centrale (Mus. Nat. Hist. Naturelle) has no manuscripts of Aug. de St. Hilaire except several fragments of the *Flore du Brèsil Meridionale* and four of his letters. Apparently there are no St. Hilaire manuscripts in the Library of the Division de Phanérogamie of the Museum except the catalogues herein described, and a single letter.

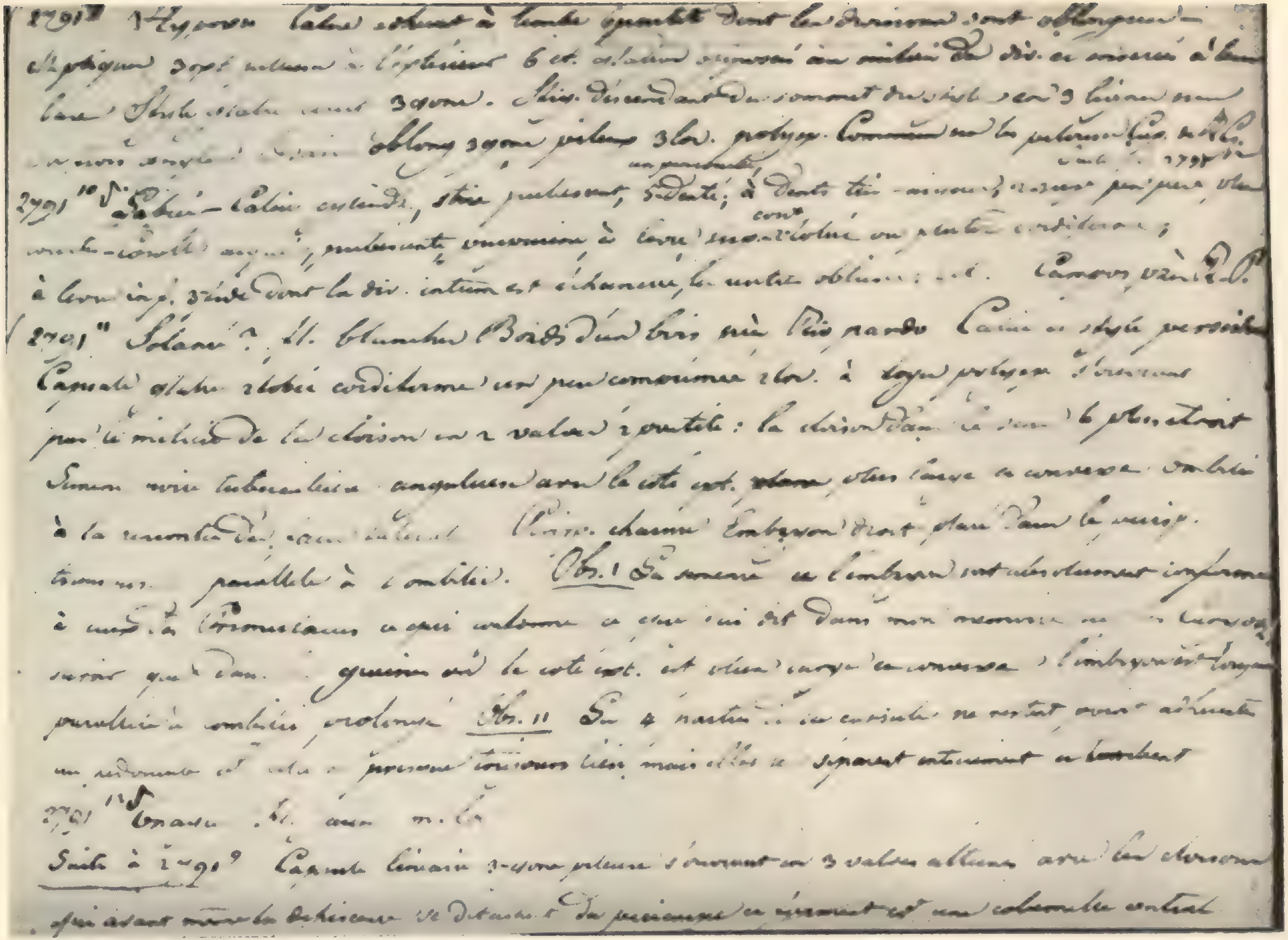
In addition, I learned that the editor of St. Hilaire's *Voyage à Rio Grande do Sul* is Charles Roland de Dreuzy (1837–1899), a native of Nivernais. He was the grand-nephew of St. Hilaire, heir to his estate at Turpinière, and grandson of a sister of St. Hilaire. At his own expense he published the *Voyage à Rio Grande do Sul,* in accordance with the last wishes of his "parent". The chateau at Turpinière is located near Ferté Saint-Aubin, Sennely (Loiret). The present owner is M. Robert de Dreuzy, son of the editor of *Voyage à Rio Grande do Sul.*

The grass described in the model "analysis" (cf. p. 157 of text) was determined by Miss Agnes Chase as *Elionurus candidus* var. *bisetosus* Hack. and Linden.

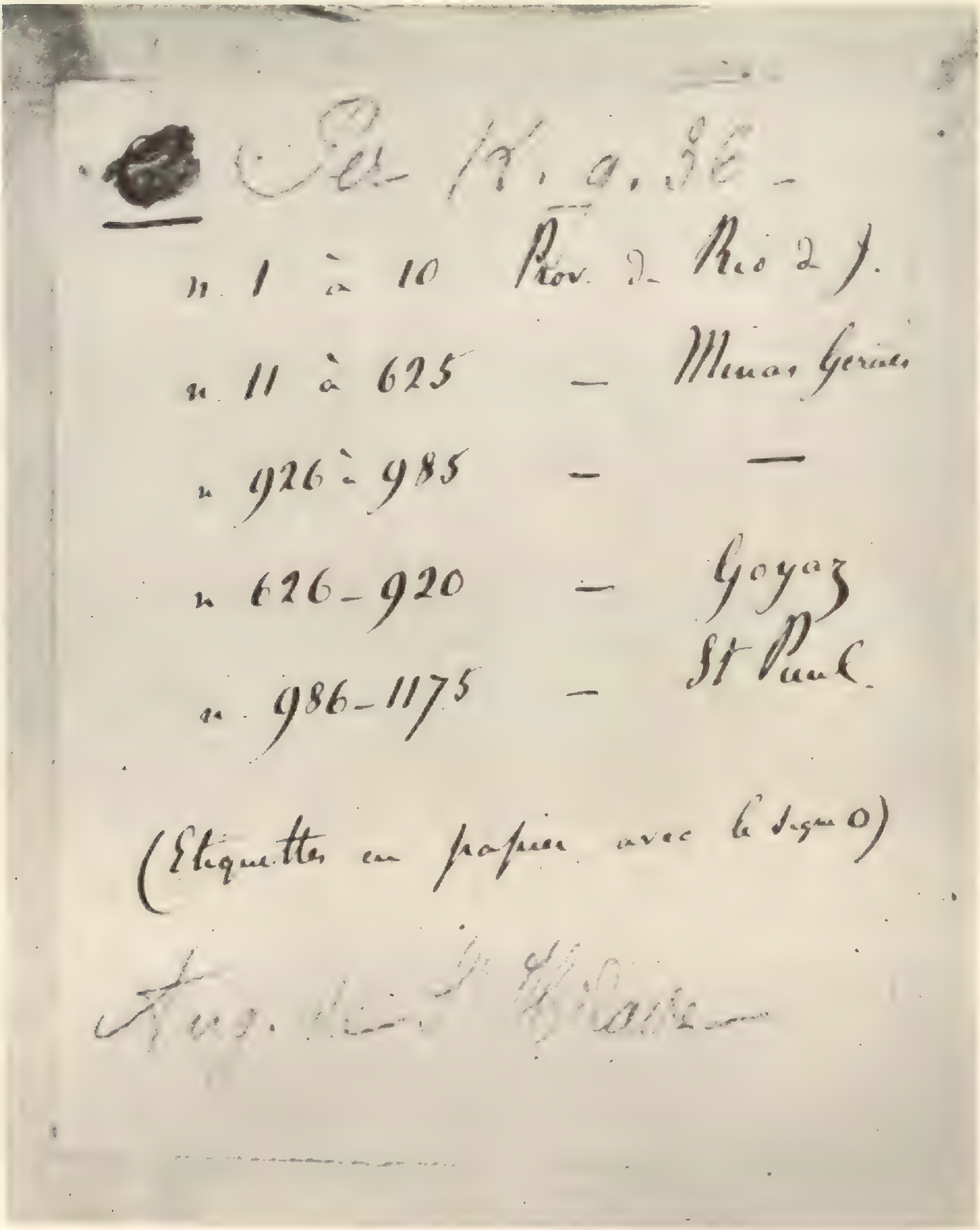
Explanation of Plate

PLATE 17

A portion of one page of Catalogue C^2 of Auguste de St. Hilaire. This is in his handwriting and covers numbers "2791^9 *Hypoxis*, 2791^{10}, Labiée, 2791^{11}, Solanée, 2791^{12}, Oranger", and "Suite à 2791^9." The last is a continuation of the "analysis" of *Hypoxis* at the top of the page.



DWYER—BOTANICAL CATALOGUES OF ST. HILAIRE



DWYER—BOTANICAL CATALOGUES OF ST. HILAIRE

Explanation of Plate

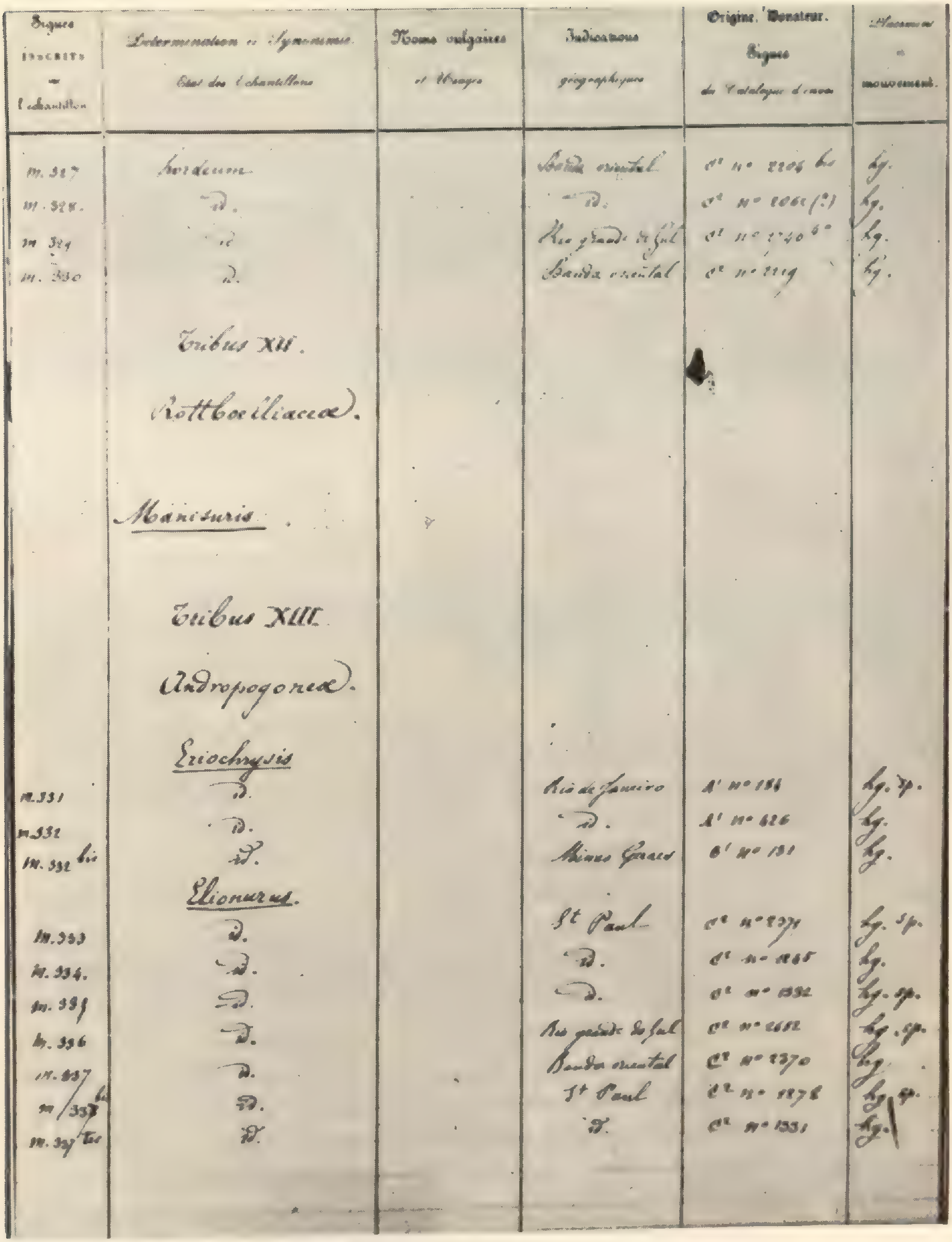
PLATE 18

A portion of the "key" to the botanical catalogues of Auguste de St. Hilaire. This is in Weddell's handwriting and is from Series C, catalogue C^1. The handwriting at the top and bottom of the page is that of the librarian.

Explanation of Plate

PLATE 19

A page from a list of approximately 2000 collection numbers of Auguste de St. Hilaire. Note that the Grasses are entered according to tribes and genera. The fourth collection entered under the genus *Elionurus* (C^2 No. 2682) is that upon which the "model analysis" (see p. 157) is based. Thelist is deposited in the Herbarium of the Muséum National d'Histoire Naturelle, Paris.



Signes inscrits sur l'échantillon	Détermination et Synonymie. État des échantillons	Noms vulgaires et Usages	Indications géographiques	Origine, Donateur. Signes du Catalogue d'envoi	Placement et mouvement.
m. 327	hordeum		Banda oriental	C¹ n° 2205 bis	hg.
m. 328.	id.		id.	C² n° 1061 (?)	hg.
m. 329	id		Rio grande do Sul	C¹ n° 2740 bis	hg.
m. 330	id.		Banda oriental	C² n° 2119	hg.
	Tribus XII.				
	Rottboelliaceae.				
	Manisuris.				
	Tribus XIII.				
	Andropogoneae.				
	Eriochrysis				
m. 331	id.		Rio de Janeiro	A¹ n° 184	hg. sp.
m. 332	id.		id.	A¹ n° 626	hg.
m. 332 bis	id.		Minas Geraes	B¹ n° 131	hg.
	Elionurus.				
m. 333	id.		St Paul	C¹ n° 2371	hg. sp.
m. 334.	id.		id.	C¹ n° 1165	hg.
m. 335	id.		id.	C¹ n° 1352	hg. sp.
m. 336	id.		Rio grande do Sul	C² n° 2682	hg. sp.
m. 337	id.		Banda oriental	C² n° 2370	hg.
m. 337 bis	id.		St Paul	C² n° 1878	hg. sp.
m. 337 ter	id.		id.	C¹ n° 1331	hg.

DWYER—BOTANICAL CATALOGUES OF ST. HILAIRE

COMPARISON OF JUNIPER POPULATIONS ON AN OZARK GLADE AND OLD FIELDS

MARION TRUFANT HALL*

INTRODUCTION

Using comparative morphology as criteria, I presented evidence in an earlier paper (Hall, 1952) that *Juniperus virginiana* L. has differentiated into five geographic races, and two of these races, called Typica and Ozark, were described in detail. Typica is known to the horticulturist as the Eastern form and may be characterized as the very tall, narrowly pyramidal tree found from Virginia to southern Illinois. Within its present distribution Typica is concordantly variable, and at least so homogeneous that it seems to be carrying no introgressant genes from other species. The influence of Typica in the juniper populations of the Ozark Plateau is not evident even though isolated plantings of this race are to be found on the western banks of the Mississippi River from St. Louis southward, usually about old farmsteads. The only other race of red cedar which occurs occasionally in the St. Louis area is the Northern, which is characterized by high frequencies of the spire-like form known as var. *crebra,* by crooked fruiting peduncles, and a preference for well-drained, sandy soils with a slightly acid reaction. I postulated that this Northern race may be the consequence of a few genes from *J. horizontalis* becoming stabilized in red cedar. The Northern race, with its tendency toward suppressed lateral branching, follows the glacial drift down the Mississippi River, and where the periglacial loess occurs these junipers are abundant. South of the loess deposits, particularly in the vicinity of St. Louis, juniper populations closely resembling the Northern race occur sporadically.

The Ozark race is indeed the most abundant and important in the St. Louis area and represents red cedar throughout the Southwest. The Ozark race, which is the result of introgression by genes of *J. Ashei* Buchholz into *J. virginiana* L., includes a highly variable assemblage of junipers distributed from central Texas across eastern Oklahoma and the Boston Mountains of Arkansas through the Missouri Ozarks to the Mississippi and Missouri rivers. Introgression by genes of *J. Ashei* into red cedar has probably occurred repeatedly, at least during the Pleistocene, and current mixing is evident in restricted areas where extensive hybrid swarms exist.

The purpose of this investigation was to determine the differences between the habitats in relation to the differences in the variability within and between populations of these Northern and Ozark races of junipers. The habitats studied are close together, less than a mile apart, and are surrounded by many hundreds of populations of junipers both large and small. It was thought that these habitats may select from this large gene pool adaptive genotypes which may vary from population to population proportionately to the habitat differences.

---

* Cranbrook Institute of Science, Bloomfield Hills, Michigan.

ACKNOWLEDGMENTS

In the spring of 1952 I was granted a leave from the Cranbrook Institute of Science to be a guest lecturer in Genetics and Evolution at the Henry Shaw School of Botany, Washington University, St. Louis, Missouri, and to take over Dr. Edgar Anderson's class during his absence. This study was part of a project undertaken by Dr. Anderson's class under my direction.

I am most grateful to Dean Henry N. Andrews for his advice and cooperation and to Dr. Anderson for his enthusiasm in regard to field studies as well as his helpful criticism. The study was carried out in the native tracts of the Missouri Botanical Garden Arboretum, Gray Summit, Missouri, which is approximately forty miles southwest of St. Louis on US Highway 66. I am especially grateful to Mr. August P. Beilmann, Superintendent of the Arboretum, for his cooperation and detailed knowledge of land use in the Ozark region.

GENERAL DESCRIPTION OF THE AREAS

The areas studied are within the Missouri Botanical Garden Arboretum, which is situated 40 miles southwest of St. Louis, Missouri, just south of the junction of Highway 66 and Highway 50 near Gray Summit, a hilly region principally of weathered dolomitic limestones in the northern portion of the Ozark highland. The climate is designated by Thornthwaite as BB^1r (humid, mesothermal, with precipitation adequate at all seasons). Records in St. Louis for the past hundred years show such variations in precipitation that no general trends are evident, so that it is difficult to judge whether climatic amelioration or deterioration is in process. The Ozark Plateau is a part of the Oak-Hickory Forest Region described by E. Lucy Braun (1950) as the Interior Highlands, Southern Division, which lies essentially south of the glacial border. Braun wrote:

> "The Southern Division is characterized by the prominence of southern species of oaks and hickories, as *Quercus stellata*, *Q. marilandica*, *Q. Shumardii* (and var. *Schneckii*), and *Carya Buckleyi* (var. *arkansana* and var. *villosa*), and in the bottomlands, *Q. nigra*, *Q. lyrata*, *Carya Pecan*, *C. myristicaeformis*, and *C. aquatica* . . . . Prairie openings, limestone glades, and balds locally interrupt the forest cover."

Those who know the Ozark landscape consider these local interruptions of forest cover as the particular mark of beauty of the uplands, and the "openness" was a major feature in selection for settlement in pioneer days. Visitors to the Ozarks from foreign countries usually are most impressed by the red cedar glades which are island playgrounds in the present-day dense oak woods. In the proper season these open areas serve as edge for much wildlife activity, and perhaps the most characteristic features in this wise are the summer call of the chuck-will's-widow and the "booming" of the nighthawk that so often chooses a glade for his target.

The soils indicate a long history of open conditions where prairie vegetation, probably maintained by fire and grazing, played a very important role in the development of soil horizons. Soils in the area are characteristic of prairie-forest

transition regions and are much like the nut-structured prairie-forest Grood soils of continental sub-humid steppes, being intermediate between chernozems and podsols. Regardless of its history of prairie development, the Ozark region has a forest climate and probably has had since the end of the xerothermic period. Thus the climax plant formation, which is of course subject to continual change, may be the oak-hickory forest which has been spreading extensively throughout Missouri roughly in the last hundred years. Beilmann and Brenner (1951) and Etter (1953) report this trend in their studies of Ozark vegetation. It is not likely that any region has ever had a vegetational mantle entirely in equilibrium with climate alone, for other factors affecting balance are legion—e. g. nature of geological substrate, grazing and browsing, fire, and man. Rather, as Sauer (1950) has pointed out, "Plant associations are contemporary expressions of historical events and processes, involving changes in environment and biota over a large span of geologic time." However, Braun (1950) stated that knowledge of these historical events and processes is very scant even though general trends seem to be quite clear.

The history of land usage in the Gray Summit area is not known in detail, but titles to land were granted beginning about 1850, nearly 50 years after the first settlers, mostly French, began to locate along the major waterways in what is now Franklin County, and over 80 years after St. Louis was founded, also by the French. Evidence of timber cutting, heavy grazing and burning variously from the time of settlement until the Missouri Botanical Garden acquired the property in 1925 is clear and common. Apparently, in the days before the settlement of the region most of the timber was found on the headwaters of the creeks and was scattered, giving a prairie- or park-like aspect presumably as a result of a somewhat drier climate than today and the effects of grazing, fire, etc. The timber, where dense enough to be called woodland, was usually situated in the rough lands or dissected headwaters of the streams where it was largely safe from fire.

Today the Ozarks are well covered with close forests, and the once open areas show signs of rapid forest encroachment; old fields develop rapidly to forest, but the glades show little invasion by woody species even when protected from fire or grazing. Steyermark (1940) made a vegetational survey of Missouri which covered fifteen years of extensive observation, and even though the survey was strictly qualitative it was detailed enough to permit rough comparisons with present-day conditions. He stressed the role of rock strata and soil, i. e., edaphic factors, in determining the distribution of plant associations. He described six plant associations and many more associes based on differences in soil, slope, and water availability; in his conclusions he favors the polyclimax concept subscribed to by Domin, Gams, Gleason, Tansley, and Du Rietz. He indicated that the glade flora was the result of edaphic factors, and in most sites would eventually support a maple-white oak association which in the Ozarks seems to be restricted to slopes and bluffs with neutral to alkaline soils underlain by limestone.

The Glade.—The Glade, which is one of several within the boundaries of the Missouri Botanical Garden Arboretum, may be characterized as a small open space

(open glade), approximately 60,000 square feet in extent, covered by grasses and junipers surrounded by a closed area (closed glade), or buffer, approximately fifty feet in width, chiefly composed of junipers and chinquapin oaks and situated on a west-facing slope (upward ENE, 10°20′). The area studied constituted a rectangle 400 × 150 feet, approximately the total extent of the open glade. In this study the term Glade refers to the open glade within the enclosure studied.

This same glade was described by Erickson, Brenner, and Wraight (1942), who demonstrated a direct correlation between the structure and composition of the glade flora and the occurrence of a dolomite stratum at or near the surface. The glade soil is very shallow (averaging about 4 inches), organically rich and derived from a dolomitic rock which under the open glade is a thin, porous dolomite locally known as "cotton-rock," an upper stratum of the Cotter Formation, and lies unconformably on the Jefferson City Formation, both in the Canadian Series of the lower Ordovician. Under the closed glade a less porous dolomite with lower magnesium content is covered by a fairly thin mantle of Union Silt Loam. The dense oak-hickory upland forest on the Union Silt Loam gives way to red cedar-chinquapin oak forest at the periphery of the glade, but wherever the "cotton-rock" occurs it drains the area sufficiently that the red cedar-chinquapin oak forest is fairly well stabilized. In winter and spring, as a consequence of greater precipitation and less evaporation, the open glade ("cotton-rock" stratum) is wet, often with standing water, while in summer and fall, when precipitation effectiveness is least, the porosity of the rock permits rapid drainage which results in rather extreme dryness in the upper few feet of the stratum. I have been frequently observing several of these glades since 1947, and, besides the rather obvious seasonal cycle of wetness and dryness, there are fluctuations every few years which markedly affect the population density of the species and the cover. In order for the perennials, in particular, to be successful in the glade community, they must be able to withstand fairly great fluctuations of the environmental conditions.

The Old Field.—The Old Field is situated on a gently sloping knoll below the orchid greenhouse. The upward slope (5°10′) is NNW facing SSE. The knoll is covered by Union Silt Loam and probably will eventually support an oak-hickory forest. On this knoll a plot 60,000 square feet in extent was laid out as a rectangle 300 × 200 feet.

Prior to 1925 the area was under cultivation in the traditional "Ozark fashion." A few acres of beans, peas, and corn were planted, rows running uphill, and tilled by means of the mouldboard plow and mule driven by a tenant farmer. In 1925, when the property was acquired by the Arboretum, this field was badly eroded and almost bare of vegetation, but since 1925 it has not been grazed or burned, and the revegetation has been accomplished in the last 28 years.

At present, the arborescent growth on the Old Field consists of scattered junipers, black oak, white ash, and thickets of red elm. Wisteria is an abundant shrub,

having invaded the field from plantings nearby. The upper edge of the sloping field supports a growth of sugar maple, white ash, black oak, shingle oak, post oak, black cherry, smooth sumac, buckbrush, and poison ivy. The middle portion of the field consists of thickets or clumps of red elm saplings with a maximum height of about ten feet, and a thick growth of smooth sumac and wisteria. On the lower slope which drains into a tiny creek are growing black oak, white ash, northern red oak, persimmon, rough-leaved dogwood, winged sumac, poison ivy, woodbine, and summer grape.

The oldest arborescent growth is made up of persimmon, post oak, black oak, and shingle oak, which apparently invaded the field approximately five years after its abandonment. Then northern red oak, sugar maple, white ash and red cedar came in six to eight years after abandonment. At any rate, the older specimens of red cedar were twenty years old, eight years having elapsed since abandonment of the field. The rate of invasion by red cedar depends on the balance of several variables such as the number and proximity of seed-producing plants, condition of the invaded area, amount of cover, slope, pH, etc. Drew (1942), in his studies of abandoned crop-land in the Cedar Creek area, Boone and Callaway counties, Missouri, found that five years after abandonment sassafras, persimmon, shagbark hickory, post oak, and shingle oak invaded; after six to seven years, American elm; after eight to ten, northern red oak, sugar maple, white ash, honey locust, and black walnut; after eleven to twelve years, red cedar and black oak.

In the herb layer the general cover consisted of fairly evenly distributed clumps of broom-sedge with Kentucky blue-grass in swales and level places bordered by clumps of little blue-stem. On the up-slope, broom-sedge, tall red-top, Canada goldenrod, and old field goldenrod were conspicuous. From midway to the bottom of the slope were these same species plus dewberry *(Rubus flagellaris)* and *Aster pilosus*. Here and there were almost bare sandy slopes, a few feet in extent, consisting of stands of triple awn-grass with a few lichens and mosses. Directly beneath the crowns of most of the larger trees were areas covered by lichens and mosses.

Cedar Hill.—Another old field, here called Cedar Hill, is an exclosure with a gentle slope from west to east mowed annually with a sickle-bar and covered with well-spaced red cedar, black oak, black cherry, honey locust, and red elm. The shrub layer consists of dewberry *(Rubus flagellaris)*, smooth sumac, trumpet-vine, buckthorn, aromatic sumac, large clumps of buckbrush, partridge pea, and seedlings of sassafras, shingle oak, and persimmon. The herb layer consists principally of Canada blue-grass, triple awn-grass, tall red-top, *Panicum capillare*, and frequent clumps of broom-sedge, scattered clumps of little blue-stem, and occasional clumps of mountain mint and ironweed. Dewberry *(Rubus flagellaris)* was scattered fairly evenly throughout the field.

The junipers average about 30 feet in height and thirty years of age, somewhat younger than those of the Glade. The juniper reproduction in the exclosure was

negligible. Although there were abundant seedlings, particularly at the edge of the crowns of those mature junipers bearing berry-cones, all were below sickle-bar height and usually under three years of age. Just outside the exclosure and in the general area juniper reproduction was very good, and ages up to thirty-five years were represented. Species composition was not analyzed because of the artificial situation. In the meadow the juniper population in an area of 60,000 square feet was sampled. In general features this meadow is closely similar to the Old Field. The soil is Union Silt Loam but much deeper since Cedar Hill lies above an old river channel. The Cedar Hill population was included in this study because of its intermediate position morphologically between the Glade junipers and those of the Old Field.

METHODS OF STUDY

Several factors were studied for the Glade and Old Field in order to make comparisons. Species composition, distribution of juniper seedlings, and the population structure of junipers were studied, and the data appear in Tables I–II, figs. 1–3, and pls. 20–21. Frequency was used as a quick method of measuring species composition. The Glade and the Old Field were divided into four plots by staking out the diagonals. Along the diagonals alternating from one side to the other, 20 quadrats (1 meter in size) were laid out, equally spaced from the center. Preliminary work was done in late spring of 1952, but other surveys were made in late spring and late summer of 1953. The presence of species in each quadrat was tabulated and the results for the Glade and Old Field appear in Table I. The areas studied seemed sufficiently homogeneous for the use of 1-meter quadrat size, specifically to determine the species composition of the herb layer. A sample area about 0.5 per cent of the total was used. A compromise in favor of a small sample area was made because of the limited time the class could be in the field.

Variations of the juniper populations were measured by pictorialized scatter diagrams as demonstrated in *Juniperus* in a previous paper (Hall, 1952). Five characters were scored: gland length-width ratio; length of whip (longshoot) leaf; length of terminal whip; length of lateral whip; on secondary shoots, the per cent of tertiary branches which have the decussate leaf arrangement. Two of these characters were also analyzed by use of the parameters of the log-normal curve which the data fit. These data, when plotted on logarithmic probability paper, result in a straight line.

In an attempt to get some estimate of seed-dispersal pattern, the distribution of seedlings was studied. Observations were made to determine the role that birds, mammals, and gravity may play in seed dispersal.

SPECIES COMPOSITION

Rough comparisons were made of species composition of vascular plants for the Glade and the Old Field. Only one quadrat size was used and no attempt was made to obtain quantitative data on density or cover. For convenience a frequence index after the method of Raunkiaer (1918) was made up for the Glade and the

Old Field. The percentage of frequence for a given species is the percentage ratio the plots on which the species occur bear to the whole number of plots sampled. Raunkiaer found that the greatest number of species had the least frequence; and that as the frequence increased the number declined steadily, until at the highest frequence the number increased slightly. Raunkiaer used five frequence groups, A, B, C, D, and E, designating the species of frequence 1–20 per cent, 21–40 per cent, 41–60 per cent, 61–80 per cent, 81–100 per cent, respectively. His law of distribution, determined from quadrat studies in Europe was $A > B > C \overset{\geq}{\underset{<}{=}} D < E$; the actual percentages were approximately 53, 14, 9, 8, 16. In eastern America, Kenoyer (1927), found that 69, 12, 6, 4, 9 per cent were more characteristic.

In this study the Glade had a frequence index of 28, 8, 2, 2, 2 or $A > B > C = D = E$. This index is similar to that found by Kenoyer in his studies for America and indicates a fairly high proportion of sporadic species and a very few acting in a "dominant" role. The Glade has uniformly distributed patches of *Sporobolus neglectus,* and the size of each patch fluctuates somewhat from year to year. When the patches are smaller, more *Bouteloua curtipendula* and forbs are in evidence. In good years the Glade has a good cover contributed principally by a very small number of species even though there is an appreciable number of sporadic species between the clumps of the cover plants.

The Old Field index was 22, 3, 8, 5, 0 or $A>B<C>D>E$. This somewhat irregular result is a product of the heterogeneous nature of the Old Field flora. There are a large number of sporadic species, a fairly large number of species intermediate in frequence, and no "dominants." The floral composition and vegetational structure are markedly different from those of the Glade. Factors of competition and selection are less delicately balanced in the Old Field, and these factors undoubtedly cause the population structure of the junipers there to be different from that of the Glade.

Table I lists the species and their frequencies found in sampling 0.5 per cent of the area studied. Only the under-story is represented. Woody plants in the list were seedlings or sprouts in size class 1 (0–0.9 feet) of Weaver and Clements (1938). The Old Field had seven species of woody plants represented in this size class for the area surveyed, which compares with nine species of similar size found by Drew (1942) to be common in old fields twenty-five years after abandonment. In the Old Field all sizes of woody plants were abundant up to size class 4 (3.6–9.5 inches D.B.H.), but on the Glade very few specimens larger than size class 1 were seen, suggesting a high seedling mortality. The frequency data in Table I show that the Glade and Old Field are quite different in species composition and suggest a difference in the pattern of succession. The Glade is a "prairie" association with *Andropogon scoparius* and *Rudbeckia missouriensis* contributing most to its aspect and with *Andropogon scoparius* and *Sporobolus neglectus* contributing most to the cover. Even though there is some fluctuation in abundance from year to year. there are definite dominants, a good variety to the flora, and a stability in its overall composition which suggests that succession is very slow and that the Glade

TABLE I

SPECIES LIST WITH FREQUENCIES FOR UNDER STORY OF GLADE AND OLD FIELD*

Glade	Frequencies	Old Field
1. *Sporobolus neglectus*	1.00	————
2. *Carex Crawei*	.90	————
3. *Andropogon scoparius*	.80	*Poa pratensis*
4. *Houstonia longifolia*	.75	*Rubus flagellaris*
5. ————	.70	*Andropogon virginicus*
6. ————	.70	*Aster pilosus*
7. ————	.65	*Desmodium glabellum*
8. *Euphorbia corollata*	.60	————
9. *Rudbeckia missouriensis*	.55	*Rumex hastatulus*
10. ————	.55	*Oxalis stricta*
11. ————	.50	*Panicum virgatum*
12. ————	.50	Lichens
13. *Sisyrinchium campestre*	.45	*Erigeron strigosus*
14. ————	.45	*Taraxacum officinale*
15. ————	.45	*Hieracium Gronovii*
16. ————	.45	*Campsis radicans*
17. *Hypericum prolificum*	.40	*Triodia flava*
18. *Gaillardia pulchella*	.40	————
19. *Echinacea pallida*	.40	————
20. *Ruellia humilis*	.35	————
21. *Oenothera missouriensis*	.35	————
22. *Heliotropium tenellum*	.35	————
23. ————	.30	*Achillea millefolium*
24. *Viola pedata*	.25	*Parthenocissus quinquefolia*
25. *Selaginella rupestris*	.25	Mosses
26. *Juniperus virginiana*	.25	————
27. *Viola papilionacea*	.20	*Ulmus rubra*
28. ————	.20	*Celtis occidentalis* var. *pumila*
29. *Coreopsis lanceolata* var. *villosa*	.15	*Hypericum punctatum*
30. *Ulmus rubra*	.15	*Prunus serotina*
31. ————	.15	*Cercis canadensis*
32. ————	.15	*Rhus aromatica*
33. Mosses	.10	*Juniperus virginiana*
34. *Eleocharis compressa*	.10	*Asplenium platyneuron*
35. *Aster oblongifolius*	.10	*Ambrosia artemisifolia*
36. *Zizea aurea*	.10	*Allium vineale*
37. *Monarda citriodora*	.10	*Solanum carolinense*
38. *Cercis canadensis*	.10	*Carex Haydenii*
39. *Rhamnus caroliniana* var. *mollis*	.10	*Eragrostis spectabilis* var. *sparsihirsuta*
40. *Comandra Richardsiana*	.10	————
41. *Lotus americanus*	.10	————
42. *Orobanche uniflora*	.10	————
43. *Acalypha graciliens*	.10	————
44. *Panicum virgatum*	.10	————
45. *Triodia flava*	.05	*Veronica arvensis*
46. Lichens	.05	*Asclepias syriaca*
47. *Bumelia lanuginosa* var. *oblongifolia*	.05	*Acer saccharum*
48. *Fraxinus americana*	.05	*Physalis pruinosa*
49. *Monarda Russeliana*	.05	*Pentstemon pallidus*
50. *Acer saccharum*	.05	*Sporobolus neglectus*
51. *Anemonella thalictroides*	.05	*Daucus pusillus*
52. *Bouteloua curtipendula*	.05	*Antennaria fallax*
53. *Silphium laciniatum*	.05	*Potentilla recta*
54. *Psoralea esculenta*	.05	*Galium aparine*
55. *Quercus Muehlenbergii*	.05	*Poa compressa*

Glade	Frequencies	Old Field
56. *Pellaea atropurpurea*	.05	*Rhus Toxicodendron*
57. *Fimbristylis Drummondii*	.05	————————
58. *Petalostemum purpureum*	.05	————————
59. *Symphoricarpos orbiculatus*	.05	————————
60. *Pentstemon pallidus*	.05	————————

* Nomenclature after Gray's Manual of Botany, 8th edition, 1950.

community is one of real integrity. Because of the uniformity in distribution of *Andropogon, Sporobolus,* and *Bouteloua* the quality of the cover on the Glade can be determined fairly well with frequency data. In a good year the clumps of *Andropogon* are larger, denser, and more frequent. The *Sporobolus* effectively fills in between the clumps. In a dry or unseasonable year the *Andropogon* may lose ground, the *Sporobolus* to a lesser extent, but the *Bouteloua* may increase considerably. Thus, one can tell when the Glade is in good condition, so far as climatic fluctuations are concerned, by the relative frequencies (or preferably cover) of *Andropogon scoparius* and *Bouteloua curtipendula.* I think the Glade's general aspect and its severe selection against trees, shrubs, and woodland herbs, particularly as evidenced by selection against all but very *Ashei*-like junipers, support the conclusions of Erickson, Brenner, and Wraight (1942) that these glades are edaphic sub-climaxes.

The frequency data show the Old Field to be fairly typical for the Ozarks. There are several abundant species, but none of these contribute decisively to the field's aspect or cover. *Poa pratensis, Andropogon virginicus, Panicum virgatum, Triodia flava,* and *Rubus flagellaris* are conspicuous. While the number of species is much the same for the two areas, the Old Field has fewer species with high frequencies or very low frequencies, and more with average frequencies. The Old Field is obviously in a rapid stage of succession toward woodland.

Several other species were not found in the quadrats sampled. Mostly, these are not common plants in these areas but in some cases may occur with frequencies of 5 or 10 per cent in localized areas of the Glade or Old Field. The following species occurred on the Glade but did not occur in the quadrats: *Ulmus rubra, Celtis occidentalis, Physocarpus opulifolius, Amelanchier arborea, Rosa carolina, Prunus serotina, Rhus glabra, R. aromatica, Ilex decidua, Celastrus scandens, Acer saccharum, Cornus Drummondi, Diospyros virginiana* var. *pubescens, Fraxinus quadrangulata, Viburnum rufidulum, Sporobolus heterolepis, Elymus virginicus* forma *hirsutiglumis, Allium stellatum, Menispermum canadense, Psoralea psoralioides* var. *eglandulosa, Linum sulcatum, Petalostemum purpureum, Croton monanthogynus, C. capitatus, Asclepias tuberosa* ssp. *interior, Triosteum perfoliatum, Vernonia crinita, Kuhnia eupatorioides* var. *corymbulosa, Hypericum perforatum, Amsonia illustris, Isanthus brachiatus, Ruellia humilis, Solidago rugosa* var. *aspera, S. rugosa* var. *celtidifolia, S. nemoralis,* and *Parthenium hispidum.* A

total of 80 species of vascular plants was collected on the Glade (45 from the quadrats; 35 by systematic search). Eighteen other species, mostly seedlings of the woody species already mentioned, were found in the Old Field but not in the quadrats. According to experience and estimates, it seems likely that slightly over 100 species may be found in similar areas the size of the Glade and Old Field. Since these studies did not run continuously through the seasons involved, a considerable number of species was probably missed. It is also obvious from the data that a sampling area 0.5 per cent of the total is too small for best results; an area between 1 and 2 per cent would have been effective.

The closed glade is a tension zone between the open glade and the oak-hickory woodland. It is a mixture of the open glade and oak-hickory woodland floras, but most of the cover in the arborescent layer is from juniper and chestnut oak. The transition from one community to the other seems abrupt since it occurs over a short distance, usually from 50 to 100 feet. From transect studies in the closed glade I listed 75 species, 39 of which were frequent species in the oak-hickory woodland and 43 were frequent in the open glade (Glade).

Plate 20 shows the aspect of the Glade with close-ups of two quadrats (1 meter in size) on the up-slope and two on the down-slope. Plate 21 shows the Old Field aspect with two quadrats up-slope and two down-slope.

DISTRIBUTION OF JUNIPER SEEDLINGS

The diagonals and sides of the Old Field and the Glade were used as transects for seedling counts. All juniper seedlings were counted within one-half meter on either side of the diagonals and one meter to the inside of the area boundaries. Seedlings were divided into three classes as follows: Class 1, 18 inches or less; Class 2, 18.1–36 inches; Class 3, 36.1–72 inches. Total number of seedlings reported is based on counts in approximately one twentieth of the total area.

In the Old Field, a total of 621 seedlings was estimated, of which 276 were in Class 1, 207 in Class 2, 138 in Class 3. The actual number is probably somewhat higher since the smaller seedlings are rather easily overlooked. The seedlings were not distributed at random, but were either clumped about the mature (fruiting) female trees (with over 90 per cent of them on the down-slope side), or were more or less aggregated at the bottom of the slopes or in other areas where materials carried by run-off water are deposited. Birds play an important role in the distribution of seedlings in the Old Field. Many young seedlings were clustered below the branches of shrubs and trees other than junipers. A very few were found on isolated knolls and in the open where they may have been deposited by birds in flight or by ground-feeding birds.

The Glade supported a great many more seedlings under four years of age than did the Old Field. The estimate was: Class 1, 6,672; Class 2, 10; Class 3, 12. The total estimate was 6,764 seedlings for the 60,000 square feet of glade exclosure. These were distributed much as in the Old Field, but even more uniformly because of the greater uniformity of the 10° slope characterizing the Glade. The seedlings

were either clumped on the down-slope side of the mature (fruiting) female trees or were aggregated at the bottom of the Glade slope where the *Sporobolus neglectus*, because of its increasing cover toward the lower edge, acted as a brake to tumbling berry-cones carried by run-off water. There were numerous seedlings in the open, probably from seeds deposited by birds. Great flocks of robins and cedar waxwings are a common sight on the glades, particularly in the fall after the crop of berry-cones has ripened. Fortuitous fluctuations in climate probably add to the seedling mortality. In very wet seasons the seedlings with more genes of red cedar are probably favored only to be wiped out in a later year by drought. Likewise, seedlings possessing a strong *J. Ashei* component are favored in drought seasons but may suffer defeat in wetter periods.

POPULATION STRUCTURE OF JUNIPERUS

The variations in the junipers *(Juniperus virginiana)* of the Glade, Old Field, and Cedar Hill were studied, and five morphological characters were measured and plotted as pictorialized scatter diagrams. Two of the five characters, measured, gland length-width ratio and lateral whip length, were used on the ordinate and abscissa of logarithmic paper (1 $\times$ 1 cycle) and the other three as rays on the scatter diagrams. The data for the three characters plotted as rays were grouped as follows: (1) whip-leaf length: long-bar = 8 mm. or more, half-bar = 5–7 mm., no bar = 2–4 mm.; (2) per cent decussate: long-bar = 25–100 per cent, half-bar = 6–24 per cent, no bar = 0–5 per cent; (3) terminal whip length: long-bar = 80 mm. or more, half-bar = 31–79 mm., no bar = 0–30 mm. The scatter diagrams for the Glade, Cedar Hill, and the Old Field populations, as well as for populations typical for the species, are shown in fig. 1.

Population means and ranges were obtained from the grouped data (pictorialized scatter diagrams) in the manner described in an earlier paper (Hall, 1952, p. 53). The numbers given have no absolute value but represent a graded scale or index of characteristics. The scale is made up in such a way that low scores belong to *J. Ashei*, high scores to *J. virginiana*, and intermediate scores to morphological intermediates or introgressants of the two species. From these scatter diagrams the following population means on this arbitrary scale were obtained: Glade—4.35; Cedar Hill—5.48; Old Field—10.0. Typical *J. Ashei* has a population mean of 2.0–2.3; typical *J. virginiana*, Eastern race, has a mean of 9.0–10.0.

The two characters plotted on the abscissa and the ordinate for the pictorialized scatter diagrams were also analyzed by using ordered values. The data were expected to fit a log-normal distribution which was confirmed, for the data produced a straight-line function when the ordered values (from smallest to largest) were plotted on logarithmic probability paper. I followed the practical short-cut recommended by George W. Thomson of the Ethyl Corporation, which used the range as a measure of dispersion instead of the standard deviation. Statistical techniques using the range are particularly efficient with small samples.

This is an excellent method of checking the confidence of data where only an average and the range are available. The confidence limits a, b $= \bar{x} \pm ts/\sqrt{n}$,

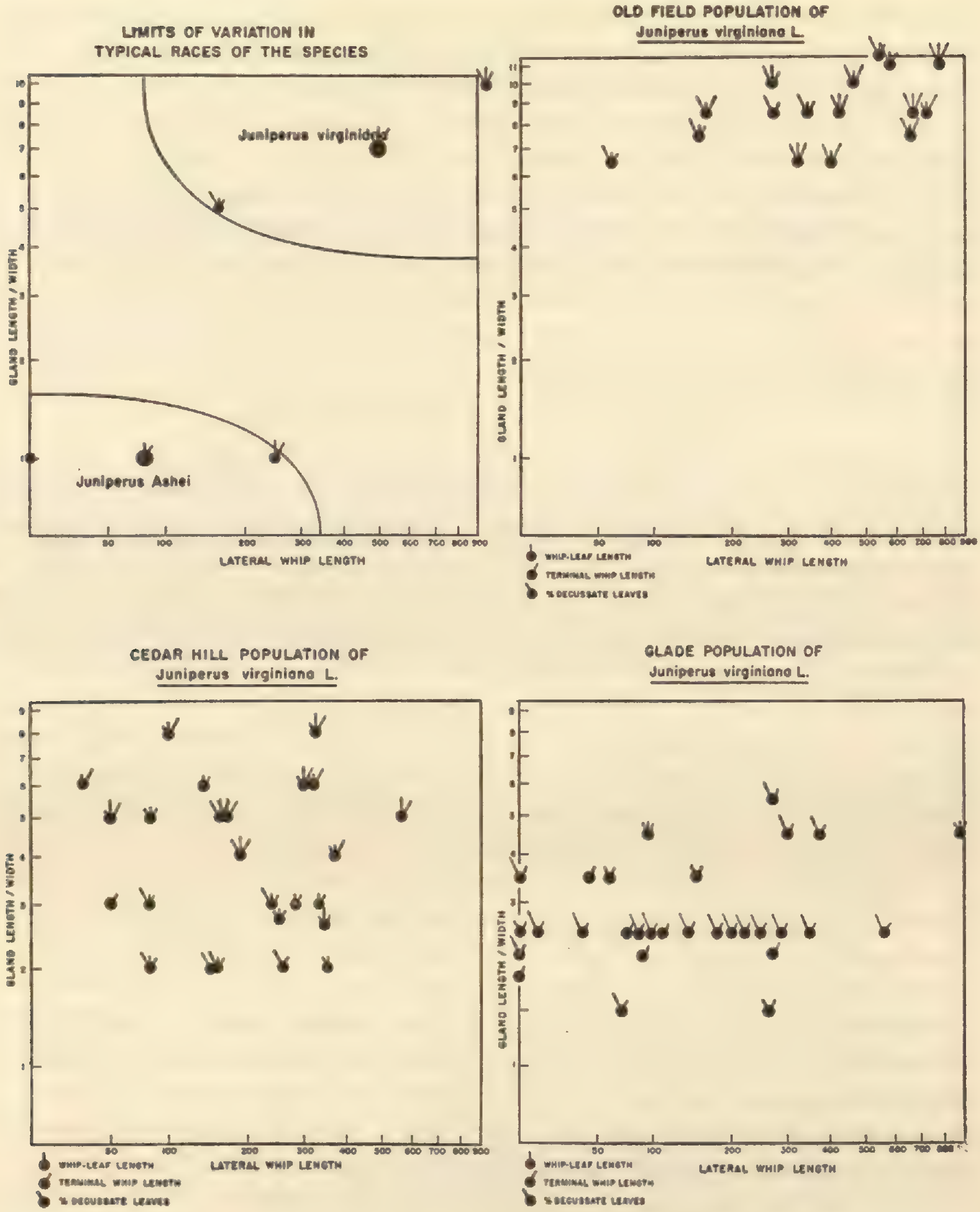


Fig. 1. Scatter diagrams showing the variations in five characters of a typical race of *Juniperus virginiana* from southwestern Virginia, a typical race of *J. Ashei* from the Edwards Plateau of Texas, and of three populations of *J. virginiana* at Gray Summit, Mo. The diagram at the upper left for the typical races shows the means (large dots), the extremes (small dots), the limits of variation (the curved lines). (The symbol in the space at the upper right of this diagram should have had three long arms.) In the diagrams for the three Gray Summit populations each dot represents a single individual.

where $\bar{x}$ is the mean, t is Student's t, s is the square root of the estimated population variance, and n is the number in the sample. Or, by using the short-cut the 95 per cent confidence limits are equal to the range multiplied by the proper value[1] (0.1064 for n = 25, 0.0720 for n = 42) plus or minus the mean.

Table II lists the population means, confidence limits, and standard deviations (log values) for two characters of each of the three populations and typical populations of both *J. Ashei* and *J. virginiana*. Figure 2 represents the ordered values plotted on logarithmic probability paper. The slopes of the lines depend on the amount of variation within each group; the greater slopes indicate the more heterogeneous populations. The point of intersection of each line with the 50 per cent value is the estimated mean for each population. The points of intersection of the 25 per cent and 75 per cent values with each line delimit the range where half the values for that character will probably lie. In fig. 3 rectangles are made about the means to correspond to the 50 per cent probability level, and the farther two rectangles are separated the greater the probability that the difference between the corresponding means is not due to chance. The dotted lines indicate the 95 per cent confidence limits of the means from Table II.

These five populations were compared to determine the probability that they represent the same population with equal means by means of the t-test. If one assumes the means of two populations to be equal, the sample difference is tested to see whether it is no more than sampling variation from the hypothetical difference, zero. Each of these comparisons led to a large t value, indicating a low probability that they represent samples from a single population. Welch's modification of the t-test was used for the comparison because the variances were not homogeneous (Comparison of $\mu_1-\mu_2$ regardless of σ_1^2/σ_2^2).

TABLE II

MEANS AND THEIR 95 PER CENT CONFIDENCE LIMITS FOR TWO CHARACTERS IN FIVE POPULATIONS OF *JUNIPERUS*

Populations	Age Class	Number in sample	Whip leaf length (mm.)			Gland length/width		
			Means	Conf. limits	Stand.* dev.	Means	Conf. limits	Stand.* dev.
J. Ashei	30 yrs.	25	4.8	(4.0–5.7)	0.179	1.0	(0.95–1.05)	0.045
Glade	35 yrs.	42	2.6	(2.3–3.0)	0.500	2.2	(2.0–2.5)	0.145
Cedar Hill	30 yrs.	25	6.8	(5.9–8.0)	0.522	3.9	(3.4–4.5)	0.187
Old Field	20 yrs.	25	7.2	(6.3–8.3)	0.140	8.1	(7.6–8.8)	0.093
J. virginiana	30 yrs.	25	8.8	(8.1–9.6)	0.088	6.4	(6.0–6.9)	0.100

* Log values.

[1]See the Appendix to this paper. The values for these multiplying factors were worked out for sample numbers from 2 to 1000 by George Thomson and appear in Table III.

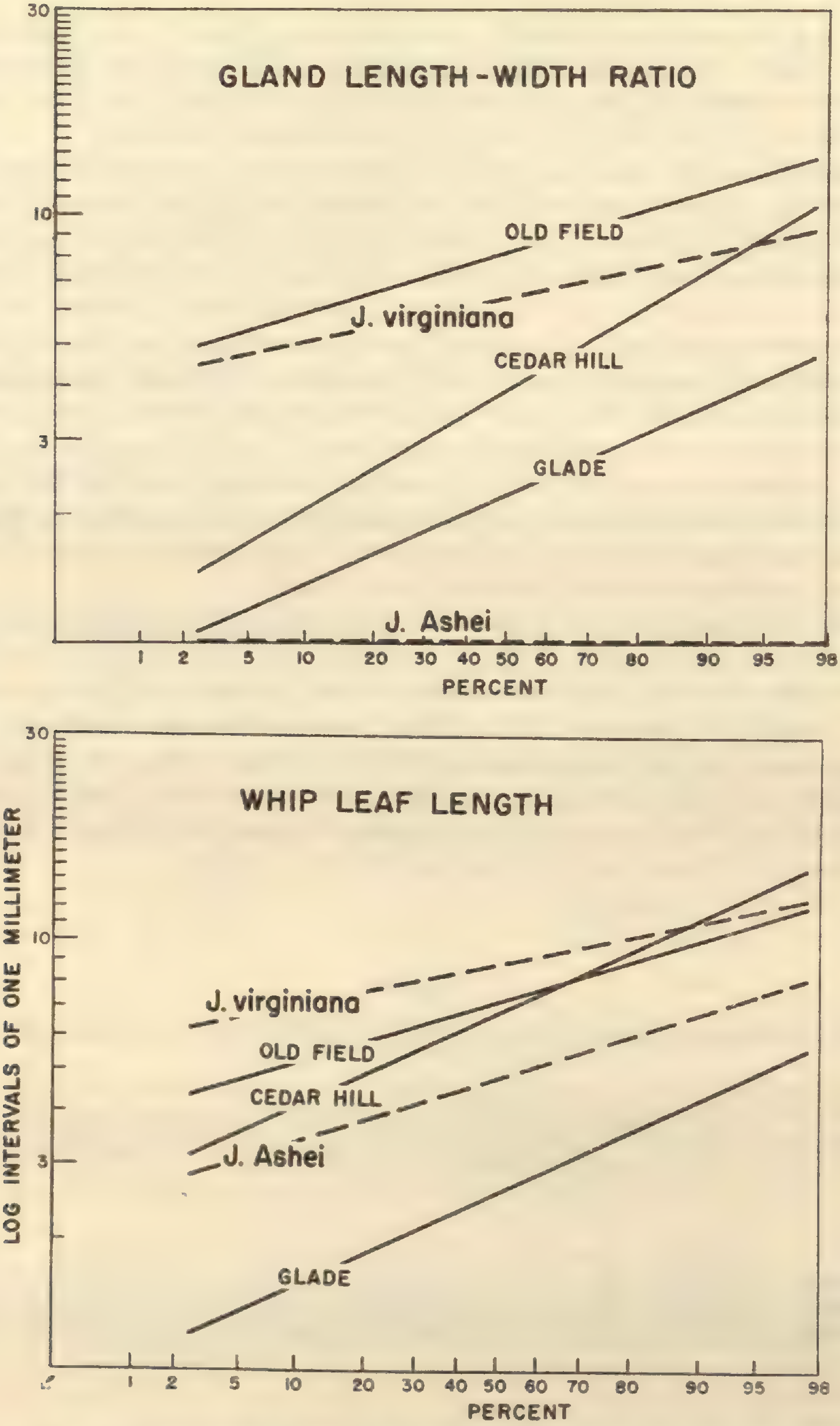


Fig. 2. Ordered values, plotted on logarithmic probability paper, for two characters for typical populations of *Juniperus virginiana*, *J. Ashei*, and the three populations of *J. virginiana* from Gray Summit. Length of the lines delimit the range where 95 per cent of the values for these two characters will probably lie.

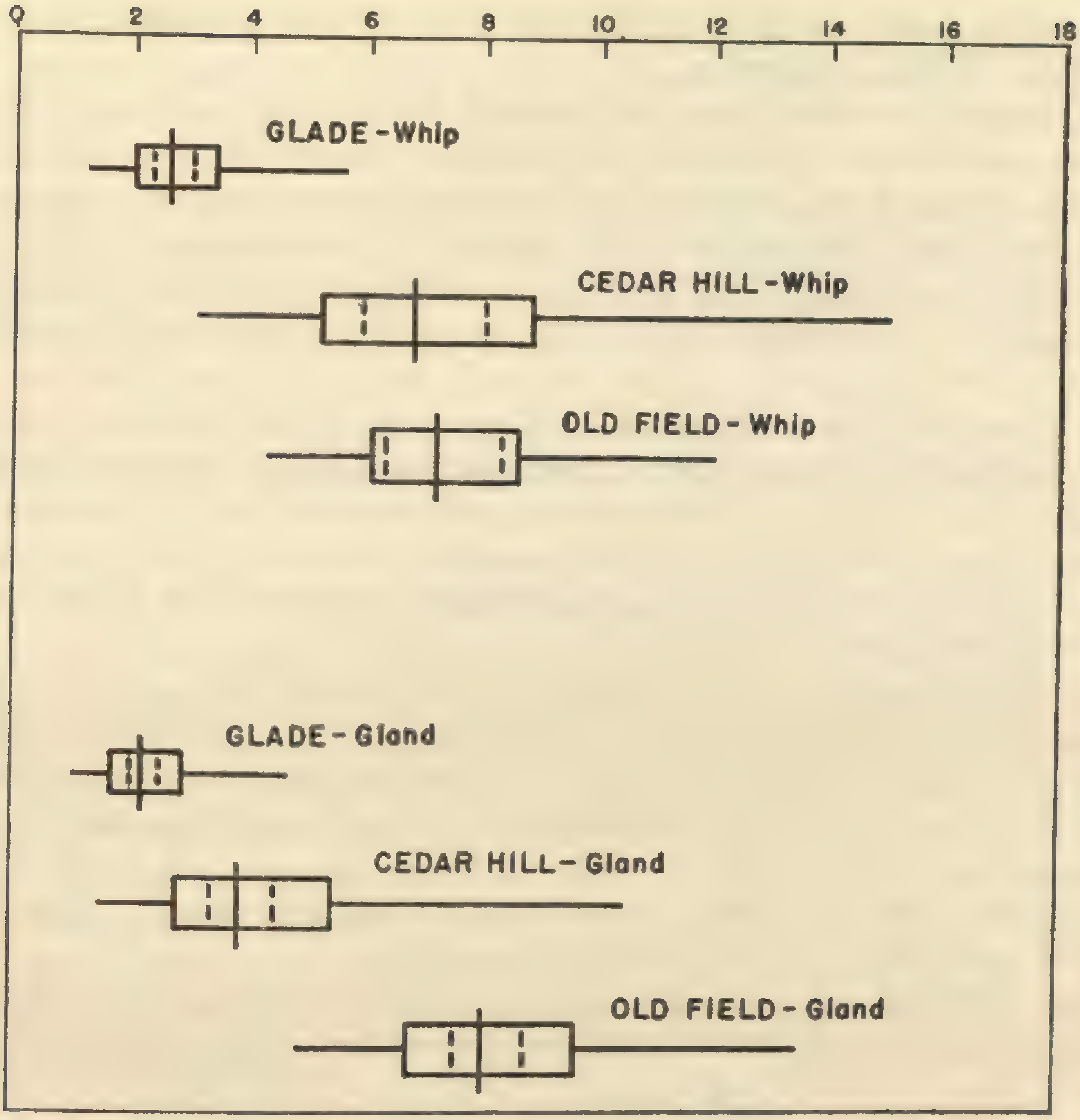


Fig. 3. Variation in whip leaf length and gland length-width ratio in the three populations of *Juniperus virginiana* from Gray Summit, Mo. The estimated means are represented by vertical bars; the 95 per cent confidence limits of the means by vertical dashes; the rectangles delimit the ranges where 50 per cent of the values will probably lie; the length of the horizontal lines delimit the ranges where 95 per cent of the values will probably lie.

DISCUSSION

In the Missouri Botanical Garden Arboretum at Gray Summit, Missouri, these three populations of *Juniperus virginiana* called here Glade, Cedar Hill, and Old Field, are each distinct, having considerably different variances and significantly different means. Each is also distinct from either species, *J. Ashei* or *J. virginiana*, which contribute to the variability of these Ozark populations. Yet, these three Ozark populations exist within less than a mile of one another, but in habitats which, at least in part, may be noted for their differences more than their similarities. In the sums of several morphological characters these populations differ from one another in nearly the same degree, so that a crude ranking using five characters

gives arbitrary values of 1.0 for *J. Ashei,* 2.1 for Glade, 3.0 for Cedar Hill, 4.0 for Old Field, 4.9 for *J. virginiana.*

Where each character is compared separately there is greater apparent difference between populations. Methods utilizing several characters therefore give a more accurate picture of the population. With several characters plotted, scatter diagrams give a good impression or "bird's eye view" of the variation within a population even though statistical inferences may not be drawn from them alone. When the populations are compared character for character, one finds that the degree of difference between characters is not necessarily similar for each character. The Glade population may closely resemble Cedar Hill in one character and more closely approach *J. Ashei* in another. Unequal variability, character for character, is characteristic of species hybrids and introgressant populations. Even when considering variation within the individual, most naturalists know that hybrids, particularly in wide crosses, have more intra-individual variability than do more typical plants of the species.

The Glade and Cedar Hill populations, both of the Ozark race, i. e. introgressants of *J. virginiana* by *J. Ashei,* are the most variable. The Old Field population is a mixture of the Ozark race and the Northern race (including var. *crebra* type) of red cedar; but as far southwestward as Gray Summit, Missouri, it occurs sporadically in disturbed habitats where the soil is sandy, light, and well drained. I have not yet seen this northern invader on a glade even though it could conceivably occur there within a favorable micro-habitat.

The Old Field and Cedar Hill habitats are very similar in every aspect but history of use by man. The Old Field was allowed to erode severely, and consequently it has less topsoil and organic matter than the Cedar Hill. The Old Field soil is more acid, sandy and coarser than Cedar Hill soil. Both Old Field and Cedar Hill soils are quite different from the very thin, organically rich, spring-wet, summer-dry soil of the Glade.

The Northern race of red cedar (including var. *crebra*) tends to be arenicolous, and even though it develops well on sandy areas overlying limestone or on the strands of marly lakes, it does best on slightly acid, well-drained strand or dune areas where competition with other plants is at a minimum. The Northern race becomes more arenicolous as it becomes more columnar or spire-like. Because of the ease with which junipers may be distributed over great distances, it is not surprising to find an occasional mixture of the Northern race of red cedar in the northeastern Ozarks. However, its occurrence there is a result of man inadvertently preparing a suitable habitat, an eroded, acidic, sandy field with poor cover. Except for the minor role the Northern race plays in introgression with the Ozark race, its effect on the Ozark populations is transient and dependent on the perpetuation of poor land-use practices. Ozark fields which have had fair treatment, particularly where cover has been protected, support stands of the Ozark race alone. In part, the Ozark race is also dependent on man since a large number of its populations occur on cleared or grazed land.

Several other factors affect the distribution and structure of juniper populations. Some of these factors are intrinsic and some extrinsic, but it is impossible to consider them independently. Rate of reproduction, per cent viability, presence of introgressive genes, character of the climatic extremes (whether unfavorable for natural seed stratification, which seems to be the situation at the northern limits of red cedar), amount of bare area in the habitat, slope, soil conditions, presence and abundance of bird and mammal species which aid in seed dissemination, role of run-off water and gravity in seed dissemination, and several other factors occur in different combinations and degrees to produce populations ranging from uniform (as in a cedar-brake) to less uniform (apparently random) to clumped. In general, when a large enough area is examined there may be found "parent" populations consisting of cores of ancient specimens which supply or supplied the seed stock for the general area. In southwestern Missouri these mother-plants may be found on the bluffs of the White River where they have fruited for centuries safe from fire and other hazards. In northern Missouri the bluffs of the Missouri and Meramec Rivers support populations of ancients. These bluff habitats of the major rivers were probably the original environment for *Juniperus* long before the Ozark glades were first colonized by junipers.

On most of the glades in the eastern Ozarks the oldest junipers are over 100 years of age, probably between 125 and 135 years. Since all the older junipers from which increment borings were taken were hollow at the center, it was not possible to get precise ring counts, but by applying a factor determined by the rate of decrease in years per inch from the center to the outside of an increment, a good estimate of age may be made. Much older trees (judged by circumference) have been found occasionally on bluffs throughout the Ozarks, but those from which increments were taken were hollow and usually with more or less eccentric rings. Such old junipers are not found in Ozark fields. In the early years of the 19th century and previously, written accounts of travels and casual reports by geologists indicate that junipers were to be found only along bluffs of the major rivers, but reports in the last half of that century presented a picture of juniper distribution much as it is today. Wherever the rocky limestone glades are burned each year, they are devoid of junipers and shrubs, giving an open grassland aspect with an abrupt transition to forest at the edges. Also, the junipers do not easily invade a glade that has been protected from grazing and supports a good stand of grass. The treeless glades, which are not uncommon, always have good cover and protection from man's grazing animals. Where glades show signs of erosion junipers are localized. In general, juniper density is proportional to the degree of land abuse, so that glades may support junipers distributed as dense "brakes", open stands with evenly but widely spaced individuals, or scattered, clumped colonies. Because of the nature of the glades slight grazing could easily weaken the cover to permit invasion of junipers where fire-sere grassland would not be so easily weakened. Before white man came to the Ozarks, wild herds probably initiated the

invasion of the glades by junipers; white man tremendously accelerated the process through his domestic animals.

In an earlier paper (Hall, 1952) I suggested that introgression between *J. Ashei* and *J. virginiana* may have begun as early as the late glacial period, followed by an expansion during the xerothermic period. Throughout this time, before settlement of the Ozarks, the most continuous habitats for junipers were the bluffs, knobs, rough glades, and youthful streams or rivers with flood-plains in an early stage of succession. Probably continuously the bluffs, knobs, and glades (edaphic sub-climaxes) were inhabited by *Ashei*-like junipers while the streams and river banks supported scattered stands of *virginiana*-like plants.

The distribution pattern of junipers in the Ozarks has probably changed radically since settlement. It is clear that the oldest junipers are situated on bluffs or glades, while old fields in the St. Louis area may support mature colonies (oldest plants up to 70 years) of the Ozark race or occasionally more youthful colonies (40 years or less) of the Northern race mixed with Ozark. From this study and cursory examination of other fields, it is evident that the condition of the land in large part determines the kind of junipers selected from the local gene pool. Literally, explosive distribution of juniper has occurred in the last hundred years, progressively increasing in amplitude as abused or worn-out land was abandoned to old-field succession. The fact that these neighbor populations, particularly Glade and Old Field, are distinct even though intermediate does not mean that hybridization between them is limited, but that each habitat is selecting the best-adapted genotypes. Natural selection is strong enough to limit the portion of the available gene pool which may be realized. Here are two powerful forces working against one another. Strong natural selection restricts the gene pool; hybridization amplifies it. With species like those of *Juniperus*, which hybridize freely and are readily dispersed, I suggest that continuously variable habitats result in continuously variable populations, and the simplest situation is when the hybridization is between two allopatric species.

Anderson (1948) stated that hybrids between two species differing in habitat requirements are expected to occupy intermediate habitats. The F_1 should occupy a habitat more or less intermediate between the two species; the F_2 should occupy more variable habitats, but the range should lie between the habitats of the species; backcrosses or introgressants should occupy habitats closest to the backcross parent. Two species may be quite interfertile, exist side by side, yet show little evidence of hybridization between them because the habitats select the parent-type combinations. If the habitat is disturbed, these available mongrels may become established. The homes of these variants are the seres either initiated by natural processes or man. While hybrid swarms and hybrid habitats are transient, they have their influence toward increasing variability both through cryptic processes, e. g. structural differentiation, and toward accelerating regional differentiation. If, for the sake of discussion, man as a producer of hybrid habitats is ignored, it will be seen that processes which initiate succession produce hybrid habitats, and indeed the edges

of ecologic systems, physiographic provinces, and climatic regions are hybrid habitats. Ecologic tension zones are hybrid habitats where species which meet may develop discordant variability. When man enters the scene, the pattern becomes more complex. Hybridization may do its cryptic work in tension zones through all levels of ecologic structure. The obvious evidence of hybridization, the hybrid swarms, are transient; and they may occur whenever the right hybrid habitat is available, but in most situations the habitats select gene combinations more like the parents and tend to keep the populations distinct.

SUMMARY

In the northeastern Ozarks *Juniperus virginiana* is represented by the Ozark race (introgressants from *J. Ashei*) on bluffs, glades, and most old fields. Occasionally, the Northern race is found locally with a little admixture of the Ozark race. Three populations of *J. virginiana* in the northeastern Ozarks were studied in detail in order to compare their variation patterns and habitats. Variation patterns were compared by means of scatter diagrams for five characters and ordered values, means, 95 per cent confidence limits, and standard deviations for two characters. The t-test modified by Welch was used to compare the means of the populations. Habitats were compared in terms of their histories, slope, soil profile, flora, frequency of species, rough estimates of cover, seedling distribution.

The evidence suggests that the three populations—Glade, Cedar Hill, and Old Field—are distinct and differ more or less proportionately to the differences in their habitats. The Glade (Ozark race) is the most southwestern in affinity, more closely resembling a population and habitat of *J. Ashei.* Cedar Hill (Ozark race) is intermediate between Glade and typical red cedar and occurs on old fields which are in good condition or, farther southwestward from Gray Summit, Missouri, on more worn-out lands. The Old Field (Northern race with a little mixing from the Ozark race) occurs on worn-out acidic and sandy lands in the vicinity of St. Louis and northeastward.

Extremely high seedling mortality (much higher on the Glade than Old Field) suggests that strong natural selection restricts the field for variability even in the face of considerable hybridization. The present balance between these two evolutionary forces depends on man making and keeping available a variety of suitable habitats. A shift in habitat qualities will result in a shift in the variation pattern of the junipers.

Distribution of age classes in the junipers indicates that the bluffs, knobs, and glades have been colonized longest by junipers, followed by the old fields supporting the Ozark race, and last the worn-out sandy, acidic fields supporting youthful colonies of the Northern race. An explosive expansion of juniper colonization resulting from man's activities seems to have occurred within the last hundred years, growing progressively as land has been worn out and abandoned. It is proposed that man is primarily responsible for the present explosive evolution in *Juniperus* in eastern North America and that if his influence were removed from

the scene, the field of variability would decline as the area of occupation contracts. Without man's help junipers would be more or less restricted to the areas in a natural state of arrested development such as the bluffs, knobs, and glades.

BIBLIOGRAPHY

Anderson, Edgar (1948). Hybridization of the habitat. Evolution 2:1–9.

Beilmann, August P., and Louis G. Brenner (1951). The recent intrusion of forests in the Ozarks. Ann. Mo. Bot. Gard. 38:261–282.

————, ————, (1951). The changing forest flora of the Ozarks. *Ibid.* 38:283–291.

Braun, E. Lucy (1950). Deciduous forests in eastern North America. Philadelphia.

Drew, William B. (1942). The revegetation of abandoned crop-land in the Cedar Creek area, Boone and Callaway counties, Missouri. Univ. Mo. Coll. Agr., Agr. Exp. Sta. Res. Bull. 344.

Erickson, Ralph O., Louis G. Brenner, and Joseph Wraight (1942). Dolomitic glades of east-central Missouri. Ann. Mo. Bot. Gard. 29:89–101.

Etter, Alfred G. (1953). Wildwood—A study in historical ecology. *Ibid.* 40:227–257.

Fernald, M. L. (1950). Gray's Manual of Botany. Eighth Edition. New York.

Hall, Marion T. (1952). Variation and hybridization in *Juniperus.* Ann. Mo. Bot. Gard. 39:1–64.

Kenoyer, Leslie A. (1927). A study of Raunkaier's [Raunkiaer's] law of frequence. Ecology 8:341–349.

Raunkiaer, C. (1918). Recherches statistiques sur les formations végétales. Kgl. Danske Vidensk. Selskab. Biol. Meddel. 1^3:1–80.

Sauer, Carl O. (1950). Grassland climax, fire, and man. Jour. Range Management 3:16–21.

Steyermark, Julian A. (1940). Studies of the vegetation of Missouri. I. Natural plant associations and succession in the Ozarks of Missouri. Field Mus. Nat. Hist. Bot. Ser. 9:349–475.

Thomson, George W. Personal communication. (Also, see Appendix).

Thornthwaite, C. W. (1931). The climates of North America according to a new classification. Geographical Review 21:633–655.

Weaver, John E., and Frederic C. Clements (1938). Plant ecology. New York.

Explanation of Plate

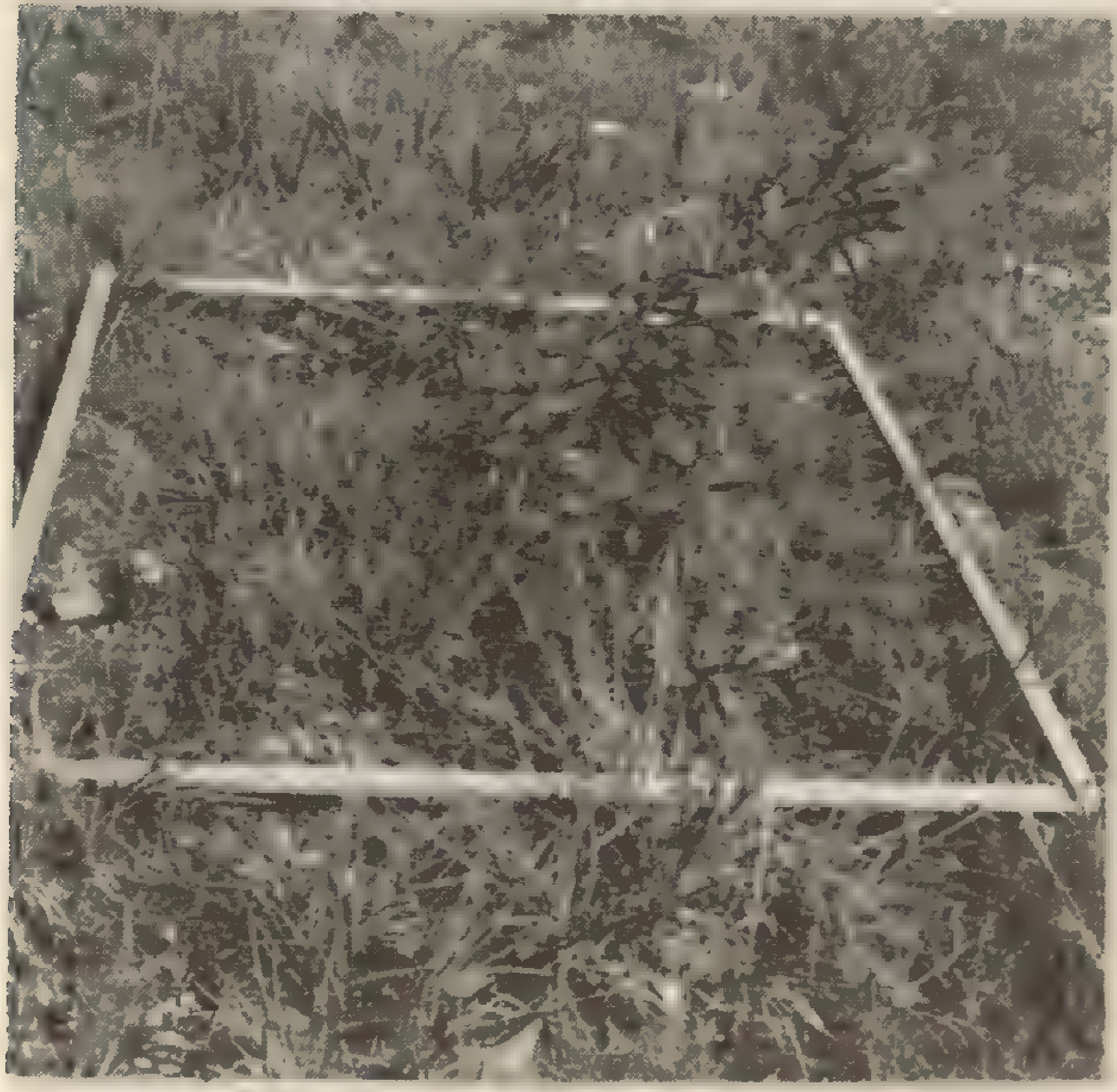
PLATE 20

Aspect of Glade

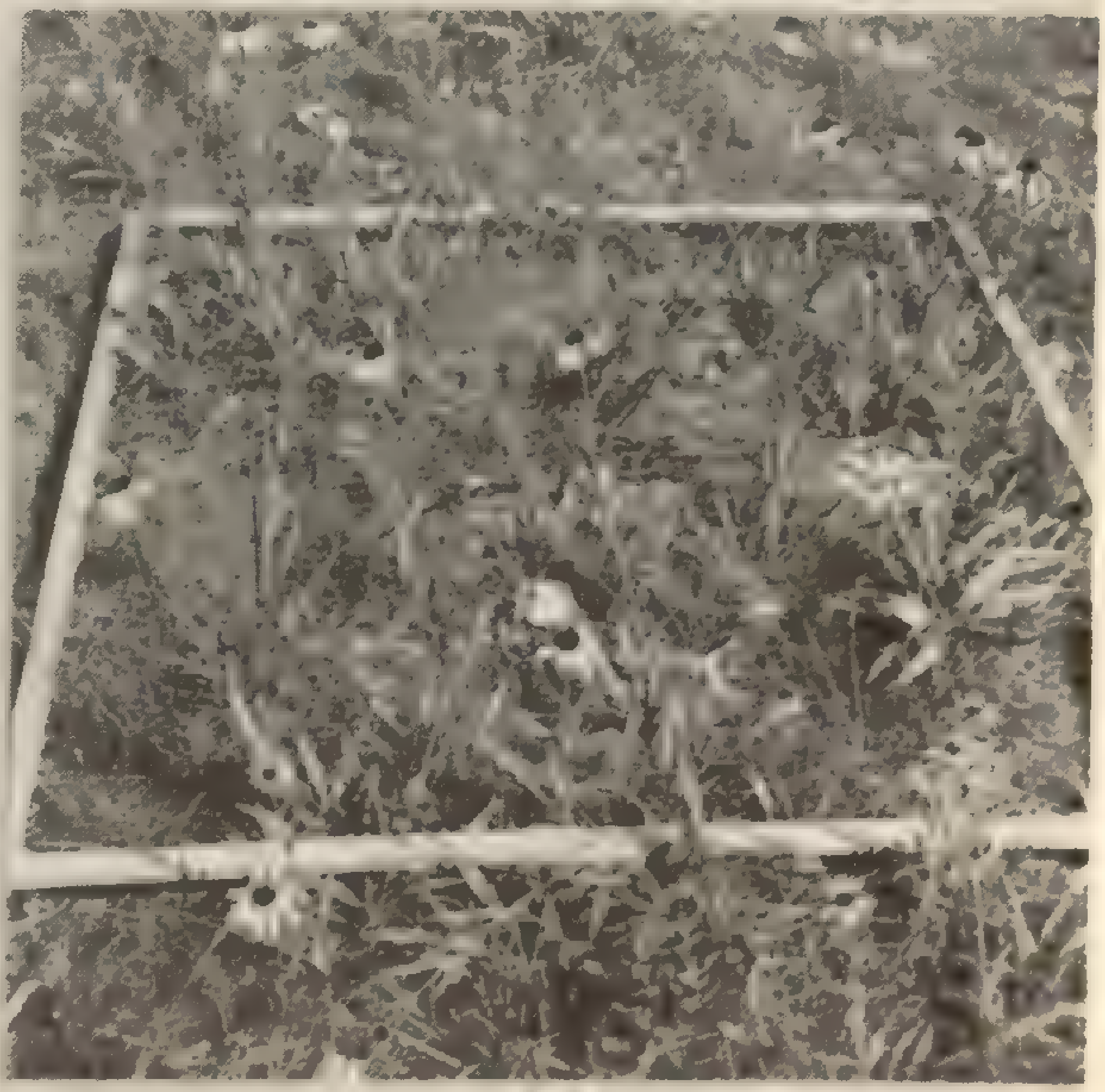
Fig. 1. Open glade looking south.
Fig. 2. Open glade looking north.
Figs. 3 and 4. Two quadrats in open-glade up-slope.
Figs. 5 and 6. Two quadrats in open-glade down-slope.

1

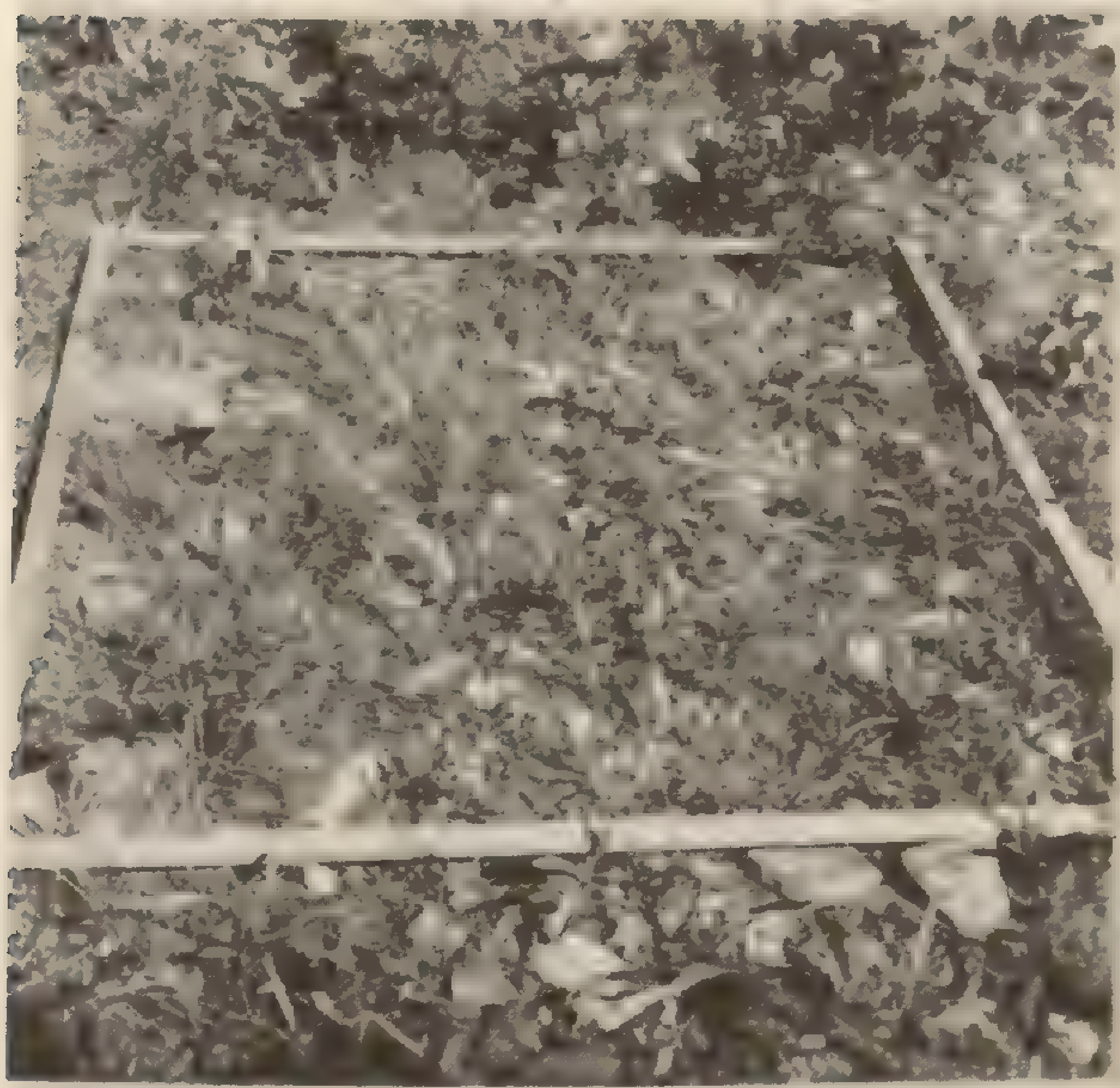
2



3



4



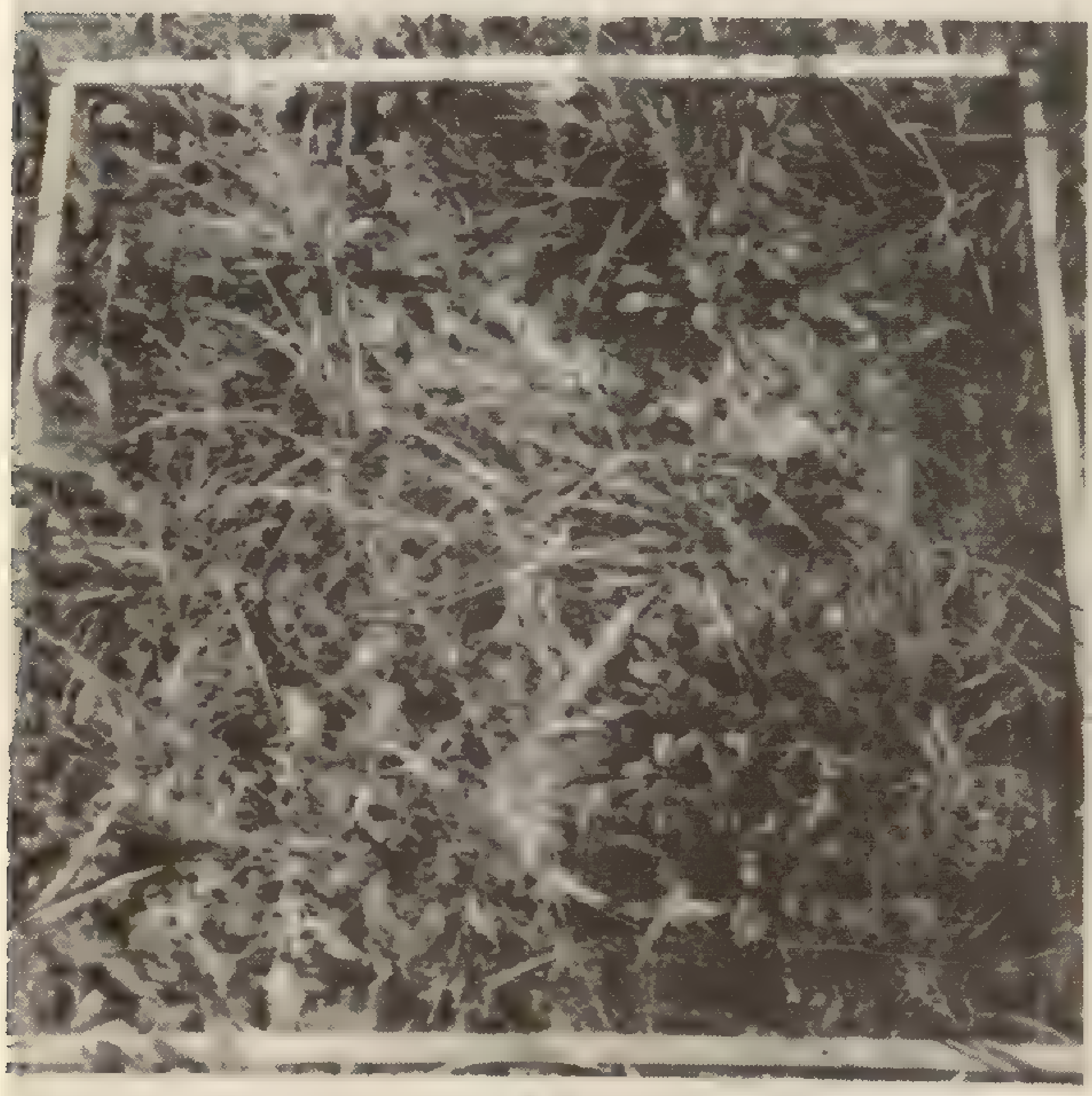
5

6

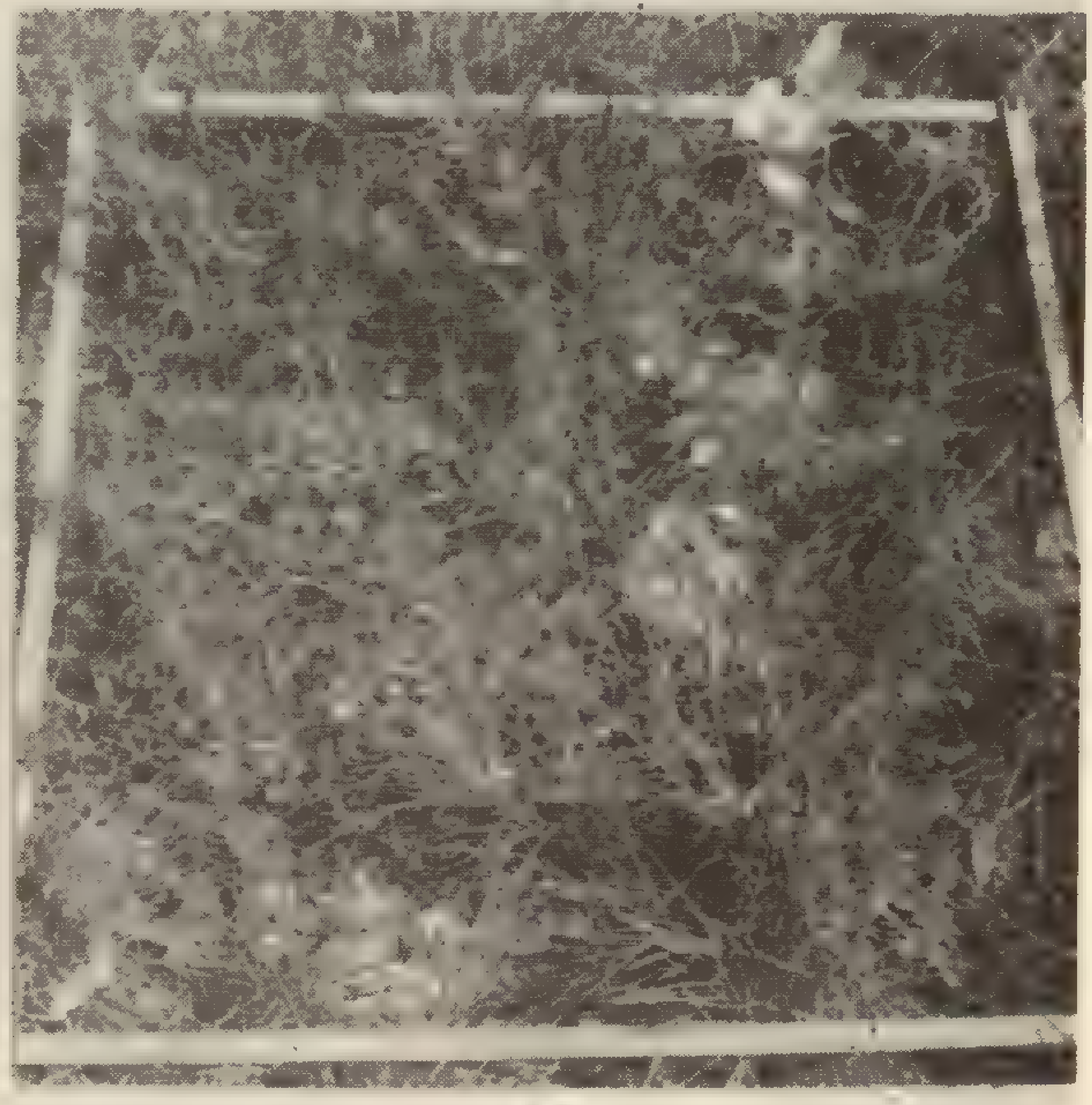
HALL—OZARK JUNIPER POPULATIONS

1

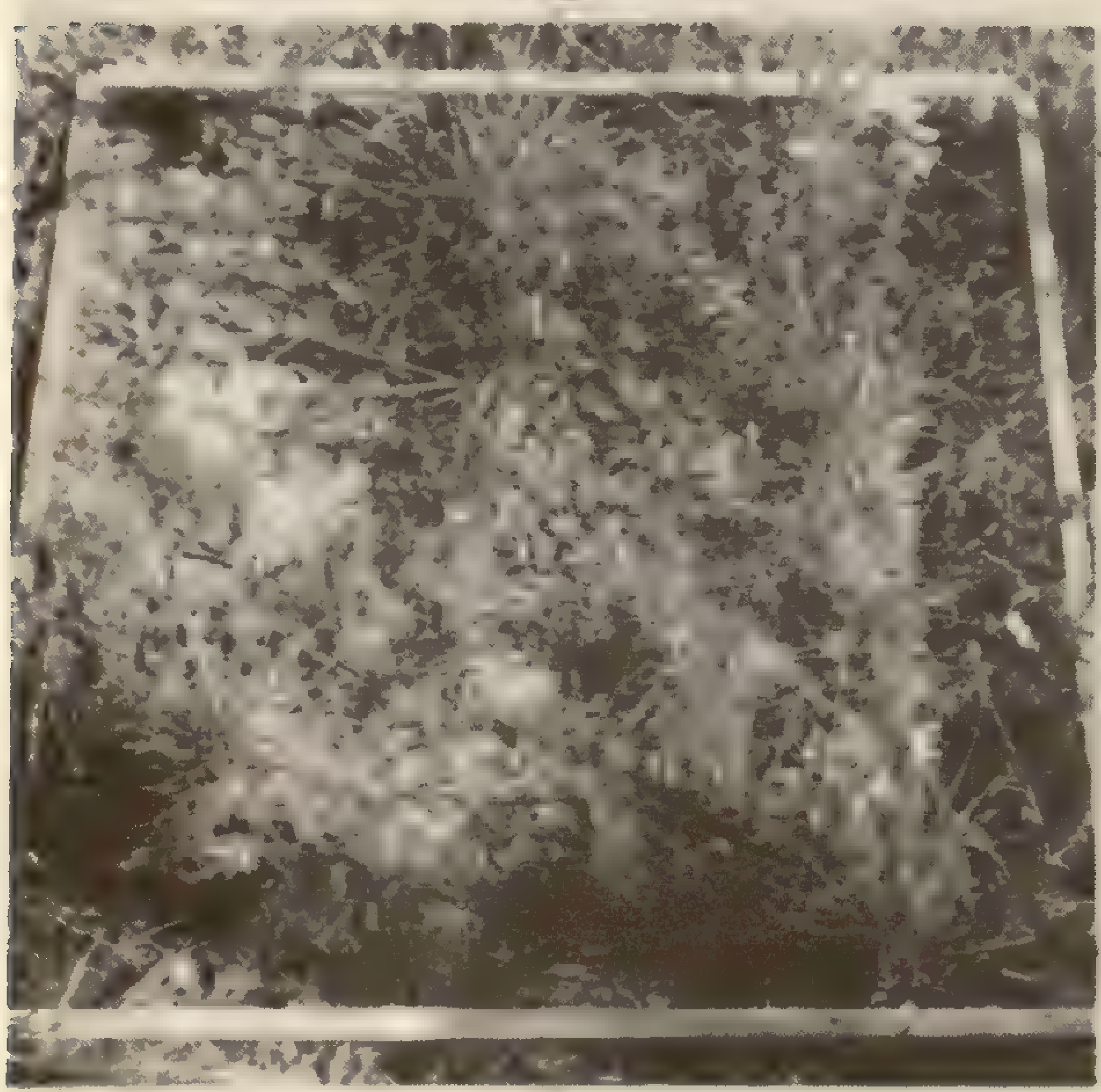
2



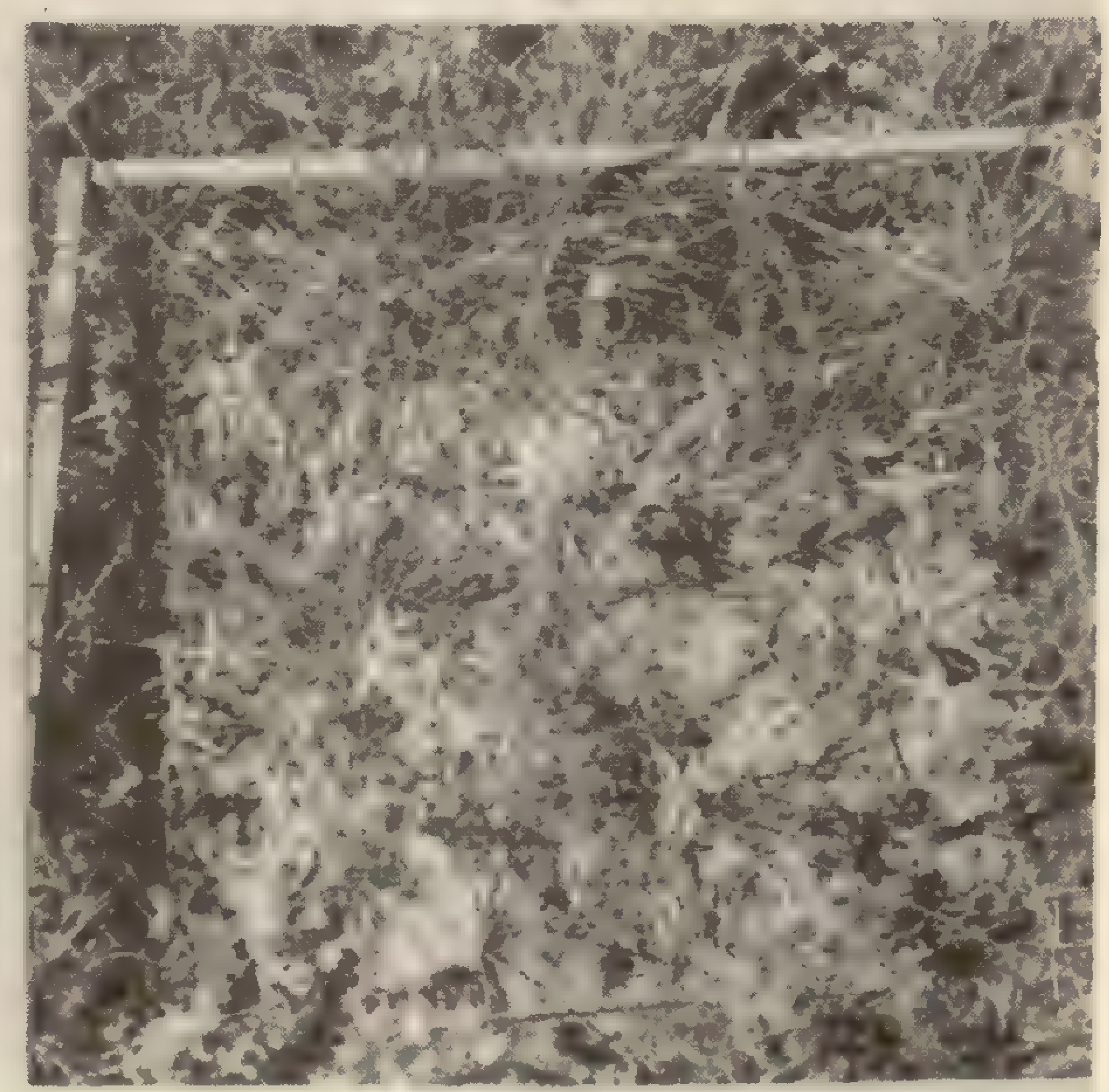
3



4



5



6

HALL—OZARK JUNIPER POPULATIONS

Explanation of Plate

PLATE 21

Aspect of Old Field

Fig. 1. Old Field begins beyond mowed area.
Fig. 2. Old Field, interior.
Figs. 3 and 4. Two quadrats, up-slope.
Figs. 5 and 6. Two quadrats, down-slope.

APPENDIX

ESTIMATION OF CONFIDENCE LIMITS OF POPULATION MEAN FROM RANGE

I am very grateful to George W. Thomson for the method by which 95 per cent confidence limits of the mean may be rapidly estimated by multiplying the sample range by a factor. Lord (1947) prepared a table of factors for sample sizes from two to twenty for six classes of probability (90–99.9 per cent). Thomson prepared a table of factors including greater sample sizes for 95 per cent probability. Thomson's table and brief discussion are published here for the benefit of other biologists who may wish to use this short method of getting 95 per cent confidence limits of the mean.

The usual method of estimating the variability of a population from a sample is by the use of the usual standard deviation estimator, s. However, recent research has shown that much more convenient estimates can be obtained from the sample range, which is defined to be the difference between the smallest and the largest values in the sample. These estimates are not as efficient in the statistical sense, but the loss is not important from a practical point of view. A useful by-product of this research is the rapid estimation of confidence limits of the mean of a normal population by the multiplication of the sample range by a factor. These results are associated with a smaller number of equivalent degrees of freedom than confidence limits based on the usual s estimates of the population standard deviation. A close approximation for the multiplying factors was found by Patnaik (1950) who approximated the distribution of the range in normal samples by the χ—distribution.

If w is the range in a sample of size n, then $w/\sigma = c\ \chi/\sqrt{\nu}$ where c is a scale factor and ν is an equivalent number of degrees of freedom for χ.

The following table extends previous calculations (Thomson, 1953) to sample sizes as large as 1000.

TABLE III

SCALE FACTORS AND EQUIVALENT DEGREES OF FREEDOM FOR X—APPROXIMATION TO RANGE IN NORMAL SAMPLES*

Numb. in sample n	Degrees of freedom ν	Scale factor c	Equivalent two-sided 5% t	Confidence limits** $\pm t/(c\sqrt{n})$
2	1.0000	1.41421	12.7062	6.3531
3	1.9846	1.91155	4.3349	1.3093
4	2.9291	2.23887	3.2265	0.7206
5	3.8267	2.48124	2.8267	.5095
6	4.6772	2.67253	2.6249	.4010
7	5.4841	2.82981	2.5038	.3344
8	6.2512	2.96288	2.4233	.2892
9	6.9818	3.07794	2.3658	.2562
10	7.6798	3.17905	2.3228	.2311
11	8.3485	3.26909	2.2894	0.2112

TABLE III (Continued)

Numb. in sample n	Degrees of freedom ν	Scale factor c	Equivalent two-sided 5% t	Confidence limits** $\pm t/(c\sqrt{n})$
12	8.9896	3.35016	2.2626	.1950
13	9.6057	3.42378	2.2406	.1815
14	10.1997	3.49116	2.2249	.1703
15	10.7717	3.55323	2.2067	.1604
16	11.3249	3.61071	2.1933	0.1519
17	11.8602	3.66422	2.1817	.1444
18	12.3789	3.71424	2.1715	.1378
19	12.8823	3.76118	2.1624	.1319
20	13.3723	3.80537	2.1543	.1266
21	13.85	3.847	2.147	0.1218
22	14.31	3.887	2.141	.1174
23	14.76	3.924	2.135	.1134
24	15.20	3.960	2.129	.1098
25	15.61	3.994	2.124	.1064
26	16.05	4.027	2.120	0.1032
27	16.44	4.058	2.115	.1003
28	16.84	4.088	2.111	.0976
29	17.23	4.116	2.108	.0951
30	17.63	4.144	2.104	.0927
35	19.38	4.268	2.090	0.0828
40	21.04	4.373	2.079	.0752
45	22.61	4.465	2.071	.0691
50	24.04	4.545	2.064	.0642
55	25.37	4.617	2.058	.0601
60	26.59	4.682	2.053	0.0566
65	27.80	4.742	2.049	.0536
70	28.91	4.796	2.046	.0510
75	29.93	4.846	2.042	.0487
80	30.98	4.893	2.040	.0466
85	31.96	4.936	2.037	.0448
90	32.82	4.977	2.035	.0431
95	33.77	5.015	2.033	.0416
100	34.61	5.052.	2.031	.0402
200	47.3	5.521	2.011	0.0258
500	67.4	6.096	1.996	0.0146
1000	85.3	6.502	1.988	0.0097

* All quantities are believed to be correct to within 3 units in the last place shown. Values for n = 2(1)10 are from Thomson (1953).

** Multipliers for range to get 95% confidence limits of normal population mean.

The following example demonstrates the use of the method. A sample size of twenty-five log values of whip leaf length from the Cedar Hill population of the

Ozark race of *Juniperus virginiana* had a range of 0.637 and a mean of 0.842. It is estimated with 95 per cent confidence that the population mean lies within 0.842 ± 0.067 or 0.775 to 0.909 (5.96 mm. to 8.11 mm.).

APPENDIX BIBLIOGRAPHY

Lord, E. (1947). The use of range in place of standard deviation in the t-test. Biometrika 34:41–67.

Patnaik, P. B. (1950). The use of mean range as an estimator of variance in statistical tests. *Ibid.* 37:78–87.

Thomson, George W. (1953). Scale factors and degrees of freedom for small sample sizes for χ-approximation to the range. *Ibid.* 40:449–450.

MISSOURI BOTANICAL GARDEN

STAFF

Emeritus Director
George T. Moore

Director
Edgar Anderson

Assistant Director
Hugh C. Cutler

Carroll W. Dodge,
Mycologist

Robert E. Woodson, Jr.,
Curator of the Herbarium

Henry N. Andrews,
Paleobotanist

Rolla M. Tryon,
Assistant Curator of the Herbarium

Hugh C. Cutler,
Curator Museum of Economic Plants

George B. Van Schaack,
Honorary Curator of Grasses

Julian A. Steyermark,
Honorary Research Associate

Frederick G. Meyer,
Dendrologist

Alice F. Tryon,
Research Associate

John D. Dwyer,
Research Associate

Nell C. Horner,
Librarian and Editor of Publications

Gerald Ulrici
Business Manager

BOARD OF TRUSTEES

President
John S. Lehmann

Vice-President
Daniel K. Catlin

Second Vice-President
Eugene Pettus

Leicester B. Faust
Dudley French
Henry Hitchcock
Richard J. Lockwood
A. Wessel Shapleigh
Ethan A. H. Shepley
Robert Brookings Smith

EX-OFFICIO MEMBERS

Arthur C. Lichtenberger,
Bishop of the Diocese of Missouri

Stratford Lee Morton,
President of the Academy of Science of St. Louis

Ethan A. H. Shepley,
Chancellor of Washington University

Mrs. Irma H. Friede,
President of the Board of Education of St. Louis

Raymond R. Tucker,
Mayor of the City of St. Louis

Gerald Ulrici, *Secretary*

Volume XLII Number 3

Annals
of the
Missouri Botanical Garden

SEPTEMBER, 1955

Tassel Modifications in *Zea Mays* . . . . Norton H. Nickerson and Ernest E. Dale 195–212

A New Species of *Doryopteris* from Surinam . . . . Karl U. Kramer and Rolla M. Tryon, Jr. 213–214

A Revision of the Genus *Celastrus* . . . . Ding Hou 215–302

PUBLISHED QUARTERLY AT GALESBURG, ILLINOIS
BY THE BOARD OF TRUSTEES OF THE MISSOURI BOTANICAL GARDEN,
ST. LOUIS, MISSOURI.

Entered as second-class matter at the post office at Galesburg, Illinois,
under the Act of March 3, 1879.

Annals
of the
Missouri Botanical Garden

A Quarterly Journal containing Scientific Contributions from the Missouri Botanical Garden and the Henry Shaw School of Botany of Washington University in affiliation with the Missouri Botanical Garden.

Information

The ANNALS OF THE MISSOURI BOTANICAL GARDEN appears four times during the calendar year: February, May, September, and November. Four numbers constitute a volume.

Subscription Price ________	$10.00 per volume
Single Numbers ________	2.50 each

Contents of previous issues of the ANNALS OF THE MISSOURI BOTANICAL GARDEN are listed in the Agricultural Index, published by the H. W. Wilson Company.

Annals
of the
Missouri Botanical Garden

Vol. 42 SEPTEMBER, 1955 No. 3

TASSEL MODIFICATIONS IN *ZEA MAYS*[1]

NORTON H. NICKERSON
Department of Botany, University of Massachusetts, Amherst and Kerckhoff Laboratories of Biology, California Institute of Technology, Pasadena

AND ERNEST E. DALE[2]
Emeritus Professor of Biology, Union College, Schenectady, New York

Zea Mays L., in addition to its great economic importance, is preeminent among plants as a tool in the study of heredity. However, even though our knowledge of maize genetics has made rapid and often spectacular advances, certain problems involving basic morphology of the plant have been left unanswered. Foremost among these is that of the pistillate inflorescence, or ear, the structure of which has been discussed elsewhere (Nickerson, 1954). Another equally basic problem involves the staminate inflorescence, or tassel. Anderson (1951) briefly summarized botanical knowledge dealing with this inflorescence, and Alava (1952) showed how certain maize races could be characterized on the basis of information obtained from their tassels.

Preliminary studies on tassel morphology by the senior author indicate that the somewhat stereotyped and simple construction of tassels is misleading; certain parts apparently have been subjected to reductions even greater than those affecting corresponding ear parts. Morphological analysis of the tassel as it occurs atop a typical maize plant is even more difficult than morphological analysis of the ear.

One source of information on ear morphology was through studies of certain genetic forms in which particular parts were present in an accentuated form. It was felt that the same technique might profitably be applied to the tassel, since variation in maize tassels is, as in other parts of this specialized grass, variation on a theme. Specimen tassels from the collecton of sixteen tassel mutants assembled by the junior author were therefore examined. They contained a wealth of material;

[1]Massachusetts Agricultural Experiment Station Contribution 994. This work, which was performed at the California Institute of Technology, Pasadena, was supported by funds supplied in part by the Atomic Energy Commission. The authors are indebted to Dr. E. G. Anderson both for his freely shared experience in careful field observation and for his critical reading of the manuscript. In addition, they wish to thank Dr. Edgar Anderson for his cooperation in this project.

[2]Present address: Division of Biology, California Institute of Technology, Pasadena, Calif.

a search of the literature revealed that, in addition to the fact that several of them had not been described, many of the known forms had very meager descriptions. Since knowledge of the tassel mutants in themselves will serve both as a preliminary step in analysis of tassel morphology and as a basis for their employment in studies involving gene interaction, fuller descriptions of these anomalous forms are given.

We have attempted to give below a careful description of how each mutant type affects structures present in tassels and ears of North American corn-belt maize. Plants of each mutant have been bred to various combinations of two widely known corn-belt inbreds, CC5 and L317, sufficiently often to allow meaningful comparisons to be made between them. It must be remembered, however, that the standard stock is largely responsible for these particular manifestations, and that the background here employed was one found to be well adapted to growing conditions in southern California. Certain forms which might logically be included in this discussion, such as Corn-grass, Teopod, Silky-1 and Silky-2, were not studied. Silkless, a well-known ear anomaly, also was not included, because in our stocks Silkless tassels are indistinguishable from those of Standard plants.

It is possible to construct a key by which these tassel mutants may be separated. However, since even in relatively homogeneous stocks, an example of one mutant may sometimes match the description of another, such an artificial device cannot be too heavily relied upon. A key is here intended only to show certain general trends among the sixteen forms; it may or may not indicate underlying genetic and physiological similarities. The several descriptions given later are arranged in the numerical order indicated in the key.

KEY TO CERTAIN TASSEL MUTANTS

A. Tassel of normal (Standard) or nearly normal proportions
- B. Tassel with silks
  - C. Pollen shed; fruits formed
    - D. Fruits on proximal branch areas from imperfect florets .... Ts_6 — 6
    - D. All fruits from perfect florets .... ts_7 — 8
  - C. No pollen shed; no fruits formed .... ts_8 — 9
- B. Tassel without silks
  - C. Glumes undeveloped .... *Vg* — 13
  - C. Glumes well developed
    - D. Glumes long (average 11.5 mm.) .... *Tu* — 14
    - D. Glumes near normal length (average 8–10 mm.)
      - E. No pollen shed .... ms_1 — 10
      - E. Pollen shed
        - F. Up to ¼ or ⅓ of branch tips sterile; pedicellate spikelets often with several sets of florets .... *bd* — 11
        - F. Branch tips never sterile; pedicellate spikelets not branched .... Club — 12

A. Tassel of abnormal proportions
- B. Tassel with silks
  - C. Half or more of tassels pistillate; staminate spikelets confined to middle areas or outer halves of branches; spikelets with no more than two florets each
    - D. Branches indeterminate, mostly ending in immature pistillate structures .... Ts_3 — 3
    - D. Branches otherwise
      - E. Spikelets loosely spaced on branches .... ts_2 — 2
      - E. Spikelets crowded on branches .... ts_1 — 1
  - C. Tassels either staminate, pistillate, or mixed; if mixed, staminate spikelets often with more than two florets

D. Extra florets developed on both sessile and pedicellate spikelets; average peduncle length 10 cm. or less........*Ts₆* — 7
D. Extra florets developed on pedicellate spikelets only; average peduncle length more than 10 cm.
E. Seed set very sparsely if at all; average glume length 6 mm........*ts₄* — 4
E. Seed set in noticeable quantities; average glume length 8.5 mm........*ts₄ᵃ* — 5
B. Tassel without silks
C. Branches horizontal or slightly lax with reference to central culm........*ra₁* — 15
C. Branches upright, close to central culm........*ra₂* — 16

Certain measurements have been made on at least fifteen and often twenty-five plants of each mutant form, and averages of these data are given in Table I. *Peduncle length* is the distance from the uppermost leaf-bearing node to the node at which the lowermost tassel branch arises. *Tassel length* refers to distance from the node at which the lowermost tassel branch arises to the tip of the central culm. *Branching area* is that distance along the central culm from the lowermost branch node below the central spike; it is included within the tassel length. *Primary branches* are axes of the second order, when the main culm of the plant is considered to be an axis of the first order. The percentage values for peduncles and branching areas were obtained by dividing these respective lengths by the sum of peduncle and tassel lengths.

These same data are presented graphically in fig. 1 by means of a pictorialized scatter diagram (Anderson, 1949). The diagram is meant only to indicate the average extent to which each of the mutants departs from average measurements of Standards. Limits were chosen so that Standard averages would always be char-

TABLE I

AVERAGE MEASUREMENTS OF CERTAIN MORPHOLOGICAL FEATURES IN TASSELS OF NORMAL AND MUTANT MAIZE FORMS

Form	Peduncle length in cm.	Tassel length in cm.	Branching area in cm.	Number of primary branches	% peduncle of whole tassel	% branching area of whole tassel
Standard	17.1	35.0	10.4	14	33	20
(1) Tassel-seed 1 (ts_1)	6.3	23.4	8.5	16	21	29
(2) Tassel-seed 2 (ts_2)	4.9	26.4	9.7	21	16	31
(3) Tassel-seed 3 (Ts_3)	3.9	22.5	9.0	26	15	34
(4) Tassel-seed 4 (ts_4)	16.2	25.2	19.1	34	39	46
(5) Tassel-seed 4ᵃ (Ts_4^a)	14.4	24.8	16.3	43	37	42
(6) Tassel-seed 5 (Ts_5)	13.0	33.5	12.4	24	28	27
(7) Tassel-seed 6 (Ts_6)	10.0	18.5	12.0	36	35	42
(8) Tassel-seed 7 (ts_7)	17.9	33.1	15.0	23	35	29
(9) Tassel-seed 8 (ts_8)	18.0	31.9	8.8	14	36	18
(10) Male-sterile 1 (ms_1)	19.0	33.3	10.8	18	36	21
(11) Branched-silkless (*bd*)	15.1	34.4	10.7	18	31	22
(12) Club (*club*)	13.9	30.3	10.8	20	31	24
(13) Vestigial glume (*Vg*)	14.9	35.3	11.7	20	30	23
(14) Tunicate (*Tu*)	13.7	33.3	12.1	22	29	26
(15) Ramosa 1 (ra_1)	14.6	33.8	28.0	72	30	58
(16) Ramosa 2 (ra_2)	12.0	27.7	21.7	67	30	55

acterized by long flags. Thus, similarity to Standard in both graph position and flag lengths means that a particular mutant departs relatively slightly from a normal form. The converse is also true; the farther away in position and the greater the flag deviations from Standard, the more a given mutant differs in form.

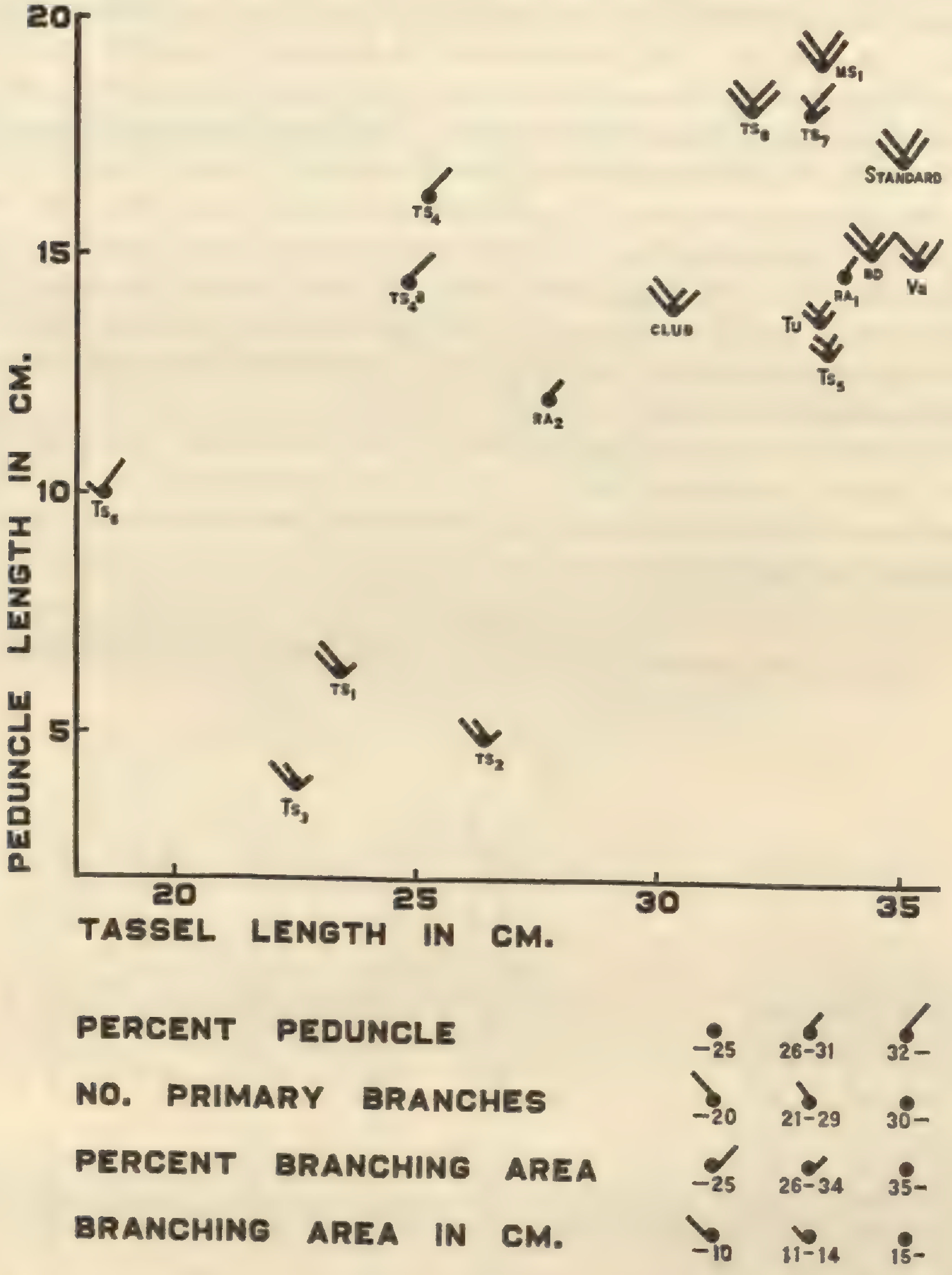


Fig. 1. Pictorialized scatter diagram of information contained in Table I, showing relationships between certain measurable features in tassels of normal and mutant forms of maize. Further explanation in the text.

DESCRIPTIONS

Standards, L317 and CC5 (pl. 22, fig. 1).—

Various mixtures of these two corn-belt inbreds were used. The history of Lancaster Surecropper, from which M. T. Jenkins developed L317, has been reviewed by Anderson (1944b). Wisconsin Inbred CC5 has an ancestry in the open-pollinated maize which was common to that section. Anderson and Brown (1952a, 1952b) showed that these corn-belt forms were various mixtures of Northern Flint and Southern Dent races. Nickerson further pointed out (1953) that these two races had previously been mixed in some degree, and that the excellent hybrid vigor manifest in present-day crosses, such as those between these two standards, is based on rather small differences. Ears are 14- to 18-rowed, 8 to 10 inches long, and bear bright yellow, dented kernels.

1. *Tassel-seed 1* (*ts_1*) (pl. 23, fig. 1).—

First described as "tassel-ear" by Emerson (1920), this mutant was classified as Tassel-seed 1 by Emerson *et al* (1935), and assigned by them to Chromosome 2. Emerson originally described the inflorescence as being completely pistillate, compact and distinctly ear-like, with "glumes and palae short, broad and rounded, in all respects much like those of true ears." He noted that these characters could be observed in both mature and immature tassels as well as in poorly pollinated mature ones. It may be added that each pair of pistillate spikelets is associated with a well-developed cupule (Nickerson, 1954). The branches are thickened so that they appear as wide green bands in adaxial view. In our cultures, as in Emerson's, seed set was good and very often both florets of a spikelet develop a caryopsis. This development obscures any evidence of regular rowing in the central spike.

Emerson noted the general plant weakness in comparison to sibs, profuse silk production in the tassel, a general lack of elongation in upper internodes, and early assumption of a pendant position by the tassel. In our stock, this pendant position is due to bending of the culm; in Tassel-seed 2, likewise a pendant form, it is attributable mostly to bending of the tassel proper. These differences are manifestations of the degree of condensation (Anderson, 1944a), at least in part. Spikelet pairs of Tassel-seed 1 are generally closely spaced, resulting in rigid branches, while those of Tassel-seed 2 are more widely spaced, resulting in lax branches. Emerson mentioned these relative spikelet-pair densities, but he did not call attention to their differing effects on the area of bending. However, his figures 10 and 11 show each form quite well.

In our stocks, branch tips most commonly end in sterile zones characterized by closely overlapping glumes. Occasionally at the very tip, these glumes simulate those of male spikelets; they sometimes even contain stamens, but no pollen shedding has been observed.

The ear of Tassel-seed 1 is slow to develop, and, as in Emerson's strains, fails to set fruit unless the tassel is either removed or poorly pollinated. It is normal except that, just as in the tassel, both florets of each spikelet often develop, obscuring evidence of regular rowing.

2. *Tassel-seed 2 (ts_2)* (pl. 23, fig. 2).—

Emerson (1920) originally described this mutant, located on Chromosome 1 (Emerson *et al*, 1935), as "tassel-seed," and noted that the tassels were loose, like those of normal plants, with individual spikelets more or less separated. Our material never showed individual spikelets, but always paired spikelets. In Emerson's specimens, spikelet pairs sometimes occurred more densely, "but not ear-like in any way." Although it rarely occurred, he noted that staminate flowers might develop with pistillate ones throughout the entire tassel, but he did not determine whether these male florets were functional. He also observed that glumes and "palae" (paleas and lemmas) of such male spikelets were long, narrow, and pointed, as in normal tassels, while in female spikelets these parts were shorter, broader, and more rounded.

In our material, spikelets were either female or perfect, no male spikelets having been observed. On perfect spikelets, glumes were elongate and near normal. Also, each spikelet pair was associated with a cupule which was often elongated above spikelet pairs located on central spike tips. Kernels developed on nearly all spikelets; in many, as with Tassel-seed 1, both florets were functional and two kernels were formed.

Each tassel branch is thin, with spikelet pairs more widely spaced in its distal portion, but the base may be as thickly set as any found in Tassel-seed 1. Tassels of this mutant are pendant, but differ from those of Tassel-seed 1 plants in that the bending is mostly accomplished in the tassel rather than in the supporting culm. This point is discussed further with regard to Tassel-seed 1 above.

Ears of Tassel-seed 2 develop to a degree depending on the fate of the tassel. If little or no successful pollination takes place, ears are developed rapidly, but always later than on normal sibs. If tassels are removed soon after their appearance, ears are formed about the same time as in normals. These results are in accord with the findings of Emerson. Like most other tassel-seeded forms, second florets in many spikelets set fruit, after the manner characteristic of Country Gentleman sweet corn (Weatherwax, 1916), so that regular rowing may be obscured. When ears develop, they are of normal size.

3. *Tassel-seed 3 (Ts_3)* (pl. 24, fig. 1).—

The first published mention of this dominant mutant was made by Phipps (1928), who stated that "a third type of tassel seed designated as Tassel-seed 3 has been studied by Emerson, but the data have not as yet been published." Emerson *et al* (1935) also listed Tassel-seed 3 as being an unpublished discovery of Emerson's. They noted that this form was similar to Tassel-seeds 1 and 2, except that the inflorescence was generally mixed pistillate and staminate, and that usually pollen could be obtained. The gene is located on Chromosome 1.

Tassel-seed 3 tassels are easily recognizable, but, like other forms, they are variable in appearance. Branches bearing distichously arranged pistillate spikelets resemble flat green ribbons on their adaxial surfaces; both branches and central spikes most often end in tapering sterile rudimentary pistillate spikelets. Often, these sterile spikelets have an appearance of being whorled rather than distichously arranged. About three-fourths of our specimens produced some spikelets from which the florets shed pollen. These staminate spikelets are imperfect, most commonly produced on proximal portions of branches and central spikes and sometimes separated by sterile zones from pistillate regions. An occasional branch is entirely staminate and ends with a zig-zag axis, but most branches which bear staminate spikelets end in the characteristic pistillate tips described above. Tassels also are lacking in stiffness, thus becoming pendant as soon as they are exserted. The upper three to five internodes of Tassel-seed 3 plants do not elongate to the degree common in Standards, and as a result a rather tight collar of leaf sheaths is formed covering the lower sixth of each tassel. One tassel in our culture was infected with smut *(Ustilago zeae)*, a probable reflection of the extreme growth and lasting succulence of tassel parts. Emerson (1920) observed, and Dr. E. G. Anderson agreed, that Tassel-seeds 1 and 2 were highly susceptible to smut, but this year we noted no infections in any of our stocks except Tassel-seed 3.

There were often instances in which a spikelet pair consisted of one staminate and one pistillate spikelet; in these mixed pairs, the staminate one is always pedicellate. No perfect florets were observed, and only one floret in any particular pistillate spikelet would form a caryopsis. Cupules are well-developed adaxial to both pistillate and mixed spikelet pairs.

The ear of Tassel-seed 3 shows very few secondary florets, although Emerson *et al* (1935) mentioned that such florets do develop. In other respects, the ear resembles that of a Standard plant.

4. *Tassel-seed 4 (ts_4)* (pl. 24, fig. 2).—

First reported by Phipps (1928), and also as Sorghum Tassel (Hayes and Brewbaker (1928), ts_4 was assigned by Emerson *et al* (1935) to Chromosome 3. Phipps described the tassel as being tassel-like in structure but predominantly pistillate-flowered, and stated that when it emerged it was a mass of silks. Our material showed tassels much shorter than normal, with an abnormal number of weak branches held upright by a tangled growth of silks. In Phipps' stock, mature tassels were studded with kernels, usually densely packed together, especially on the central axis of the tassel, and not arranged in regular rows. Our specimens varied from setting fruit to this extent to setting no fruit at all. Phipps interpreted this irregular rowing as a result of development of a second floret in each spikelet; with this finding we are in agreement. In both his material and in ours, tassel branches were short and had distichously arranged spikelets, the spikelets on the proximal branch and the lower central spike producing stamens which contained functional pollen. Tassel glumes were short and papery, but we cannot agree with

Phipps that they were similar to glumes of a normal ear; we observed no glume induration. We noted also that sessile spikelets rarely branched, while pedicellate ones often formed short branches bearing two to six spikelets. Our standard stock has an average condensation index of 1.3; spikelets may occur at a given node in pairs, in 4's, in 3's and 5's and occasionally in 6's. As in Phipps' stock, both florets of each spikelet always developed, and thus each node had at least four and occasionally as many as twelve florets in addition to possible extra ones formed on branches of proliferated pedicellate spikelets. Phipps mentioned that careful study of his material showed "a few multi-flowered spikelets."

Silks were produced only from pistils, and such florets were always imperfect. No glumes were modified into silks, as Phipps reported. It is doubtful if his observation is accurate, because he noted "the basal parts of such glumes were normal." The silk-like structures were most likely awns, and if so, they were probably produced not on glumes but upon lemmas. We observed no such structures in this mutant, but in a mutant combination not reported on here, awns are developed on the lemmas. In some tassels, spikelets were sterile, producing neither silks nor stamens. These sterile spikelets were most common on branches between the proximally located obviously staminate areas and the distally located obviously pistillate areas. Characteristic of our Tassel-seed 4 stock were both its generally light set of fruit in the tassel and production of staminate and pistillate florets in widely varying amounts. No cupules were developed adaxial to any spikelet pairs of the tassel.

Ears of Tassel-seed 4 were often shorter than normal because of failure of the tip to mature; they developed better if tassels were removed early. In our stocks, no excessive development of silks was noted, but Phipps reported that some glumes were modified into silks. Development of second florets, referred to by Phipps as common, was apparently much less common in our stock, and regular rowing was not obscured. Glumes were usually less indurated than in normal ears.

5. *Tassel-seed 4^a (ts_4^a).*—

This allele of Tassel-seed 4 was found by E. G. Anderson in a background stock of CC5 × L317 which had been exposed to radiation at Eniwetok. Crosses made by the junior author between this mutant and Tassel-seed 4 showed the two types to be allelic.

The tassel of Tassel-seed 4^a resembles that of Tassel-seed 4, but the quantity of seed set is much greater. Pollen is much more freely produced than in Tassel-seed 4. Pistillate florets which set fruit are always borne on pedicellate spikelets and are generally imperfect, but some perfect florets have been found which always appeared to set fruit. In general, pistillate florets are confined to the outer third of branches. The central spike is sometimes all staminate, with several extra florets produced on short branches which are proliferations of pedicellate spikelets. Cupules are sometimes weakly developed on the culm of the central spike, but their presence is not universal. Average lengths of glume are about half again as great as those of Tassel-seed 4.

In Tassel-seed 4[a] a few pedicellate spikelets have a tendency to proliferate slightly in the upper (distal) third of the ear. After kernels are removed, the right-angled insertion and excessive lengths of the glumes, paleas and lemmas of this allele give the cob a markedly different appearance from that of Tassel-seed 4.

6. *Tassel-seed 5 (Ts_5)* (pl. 25, fig. 1).—

Although this mutant is attributed to Emerson (1932), the only mention of Tassel-seed 5 in his paper was its inclusion on Chromosome 4 of a linkage map (see his fig. 1, p. 145). Emerson *et al* (1935), in a brief description, noted that it contained both silks and anthers but was not compacted as in Tassel-seed 4. In our material, tassels were very close to normal proportions, but they were never exserted as far as in normal sibs. Apparently this condition was due to lack of elongation of the internode directly below each tassel, as the plants appeared to be normal in height (Table I and fig. 1). Silks are much shorter and more scattered than in previously discovered tassel-seed forms. Their occurrence varies from very few being located in small branch areas (either basal or terminal), to being uniform over the entire tassel.

Spikelets may bear either staminate, pistillate, or perfect florets, but these types occur in specific places. Imperfect pistillate spikelets are usually located in proximal parts of lower branches, and when they occur on central spikes, it is only in their lower regions. Cupules are well developed adaxial to such spikelets, which most often occur as sessile members of spikelet pairs; the pedicellate ones are always both imperfect and staminate. The imperfect pistillate florets form most of the caryopses. Perfect spikelets are never associated with well-developed cupules, and seldom set fruit unless there are few or no imperfect pistillate spikelets present. Even here, however, fruits are formed predominantly on sessile spikelets. If a fruit is set in such a floret, the stamens are generally not exserted, but examination shows their anthers to be full of pollen and occasionally dehisced inside the palea and lemma. Imperfect staminate spikelets occur wherever the other two forms are absent; they never have any trace of silks, and their stamens shed pollen copiously. Silks not pollinated quickly withered.

The ear of Tassel-seed 5 in our strain developed very few second florets, but Emerson *et al* noted that "secondary florets develop in ears." Otherwise, the ear closely resembles that of our Standard stock.

7. *Tassel-seed 6 (Ts_6)* (pl. 25, fig. 2).—

The first apparent reference to this dominant mutant was made by Emerson (page 14 of the Maize Genetics Cooperation Newsletter for January, 1933). In subsequent 'Newsletters', he established that this mutant is located on Chromosome 1, but no description of its morphology has been published.

Plants of Tassel-seed 6 average about one foot shorter than normal sibs. Tassels appear at the same time, but they are only half as long and are borne on peduncles whose average length is only three-fifths as great as those of Standards. In general

appearance, the tassels resemble those of Tassel-seed 4, but they usually set a considerably greater number of fruits. Branches are numerous, short, thin, and lax, with no cupules developed adaxial to any spikelet pairs. They end in many small florets which rarely form fruits and which may be borne on whorled instead of distichous spikelets. Spikelet pairs are closely set on both branches and central spike. Scarcely any distinction exists between pedicellate and sessile individuals, as each one forms several closely packed florets. Short branches with 4 to 12 spikelets are developed on the central culm, giving it a thickened appearance. Glumes are hyaline, without chlorophyll, and extremely short, averaging about 5 mm. in length.

Tassels of this mutant have two general forms. Approximately half of them are entirely pistillate; the others produce staminate spikelets on proximal branch areas and on the lower third of their central spikes. Tassels of this latter sort may have their remaining spikelets constructed in one of three different orders which occurred in our samples with equal frequency: (1) florets bearing silks might also bear stamens and thus be perfect; (2) they may bear no stamens and be imperfect, or (3) a zone of perfect florets of variable length may grade off into a tip which is entirely imperfect. Stamens in perfect florets often neither extruded their anthers nor shed pollen, but those in staminate florets invariably shed good quantities of pollen. Silks are produced only from pistils, but an occasional lemma near a branch tip may develop a short awn.

Ears of Tassel-seed 6 are not well developed unless the tassel is removed early. There is the same characteristic production of second florets found in other tassel-seeded forms, so that regular rowing is often obscured. In other respects, ears are comparable with those of Standard plants.

8. *Tassel-seed 7 (ts_7)* (pl. 26, fig. 1).—

This mutant was found by E. G. Anderson at Pasadena in material which had been exposed to radiation at Bikini. (See Anderson *et al*, 1949, for a further discussion of radiation effects.) It is not known to which chromosome it should be assigned. Tassels have proportions and dimensions of normal ones, and, like Tassel-seed 5, have few functional pistillate florets. Silks are generally short and evenly distributed; their occurrence varies from almost none to profuse. Each silk arises from a pistil in a perfect floret; florets which do not produce silks are imperfect and staminate, producing pollen freely. Only two florets are borne on each spikelet. No cupules are developed in the tassel. The number of fruits seldom exceeds twelve per tassel, and on about half the tassels they are not formed at all.

The ear of Tassel-seed 7 commonly bears up to six short branches at its base. These branches are produced from pistillate spikelets, and an adaxial cupule is present above each one. The sessile spikelet of such a pair is generally not fully developed. These basal branches do not form any viable kernels. Silks form only slightly if at all, even though the branches remain meristematic after cessation of growth elsewhere throughout the plant. Occasionally, two or three small

branches are found on the shank below an ear. These sub-ear structures have always been sterile, and none of them developed beyond the point at which pistillate spikelets could be easily recognized.

9. *Tassel-seed 8 (ts_8)* (pl. 26, fig. 2).—

This mutant, found by E. G. Anderson at Pasadena, was segregating in a culture of chromosome translocations. It is known to be linked to white endosperm *(y_1)*. Both ts_8 and ms_1 tassels are male-sterile, in chromosome 6 and linked to y_1, but the two forms are not allelic. Further, since Ts_8 sets no fruit but produces silks and since Emerson *et al* (1935) mentioned no male-sterile forms which so behaved, the material is here described as an eighth tassel-seed form. In over-all appearance, plants resemble normal sibs. Tassels are of standard proportions and size, but glumes are occasionally shorter than normal and the spikelets never swell as time for anthesis approaches. Silk production varies from none to a profusion as great as may occur in Tassel-seed 7. Four-fifths of our population of this mutant had tassels in which no stamens were formed; in the remaining one-fifth, they were formed but their anthers were empty. No stamens are ever exserted. Silks arise from abortive pistils. Three florets per spikelet may send out silks, but no fruits are ever set regardless of ample exposure to pollen. Branch tips are often undeveloped.

The ear of Tassel-seed 8 produces a great profusion of silks; 4 to 6 are formed by each spikelet. The first silk formed (from the lowest flower) is of greatest diameter, and its pistil forms a caryopsis. Each of the others sends out a silk which generally is exserted, but no fruits are formed. Kernels are arranged in rows, and, except for the fact that many extra silks protrude between the tightly packed kernels, a mature ear resembles that of a Standard plant.

10. *Male-sterile (ms_1)* (pl. 27, fig. 1).—

This mutant was reported by Singleton and Jones (1930) and listed by Emerson *et al* (1935) as occurring on Chromosome 6. Singleton and Jones noted that tassels of male-sterile plants were more slender than normals, that anthers failed to extrude, and that no pollen was shed. They also reported that Beadle found meiosis essentially normal but that the haploid nucleus did not go through the first mitotic division, and by the time pollen should be shed it was difficult to find even the remnants of spores. Emerson *et al* noted further that shriveled anthers were exserted much later than in normal sibs.

In our material, no stamens were exserted. In other respects, tassels of ms_1 resembled those of our Standards. There was a tendency for the tassel to emerge sooner than with normals, and this tendency was reflected in slightly longer pedicels (Table I and fig. 1) since elongation ceased at the same time as in normal sibs.

The ear is normal. Singleton and Jones reported that ms_1 is closely linked to the white endosperm locus *(y_1)* with about 5 per cent recombination. Our material behaved in the same fashion; white kernels almost invariably produced male-sterile plants.

11. *Branched-silkless (bd)* (pl. 28, fig. 2.)—

First described by Kempton (1934), this mutant is listed by Emerson *et al* (1935) as occurring on Chromosome 7. Kempton noted that the division of the tassels into a central spike and branches is as definite as in normals, but that the tassels have a thickened appearance suggesting those of Tunicate plants. He attributed this thickening to development of short branches in place of paired spikelets, a condition which also occurred in our material. He also mentioned the fact that this branching was most common on central spikes, and that on the branches there was more tendency toward retaining a pedicellate-sessile form.

Kempton made no mention of sterility, nor did his illustrations show any, but in our material sterile areas occurred at branch tips and sometimes at the tip of the central spike. Not uncommonly lowermost branches were sterile throughout. In sterile areas, spikelets were less developed as distance from the central culm increased. Kempton noted that many plants shed pollen in good quantity, but stamens often were not fully exserted.

Ears of Branched-silkless are of two forms, a fact which Kempton likewise noted; his figures show each type clearly. In one type, each spikelet primordium develops into a short branch bearing female spikelet rudiments which never develop beyond the earliest stages. In the other type, such branch development is confined to the basal quarter of the ear, the upper three-fourths being composed of sterile spikelets with elongated and sometimes thickened glumes. That these branches develop from spikelet primordia on an otherwise normal cob can be easily shown by removal of the branches; underlying each pair adaxially is a well-developed cupule. It is this latter type which may occasionally produce a scattering of silks too short to become exserted. Kempton stated that his material was wholly without silks, but Emerson *et al* mentioned that the ear occurs "often without silks."

12. *Club (club)* (pl. 27, fig. 2).—

This mutant was first noted by E. G. Anderson and segregated from non-irradiated genetic stocks at the Caltech farm in Arcadia. Its chromosome length is unknown.

The tassel is shorter than normal, with branches held at angles approximating 45°. Branch ends do not droop and their thickly set spikelet pairs are fertile throughout. The central spike is exceedingly thick, and it is on account of this character that the mutant was named. This thickening is brought about by a shortening of internodes, so that the spikelets stand nearly at right angles to the central culm. Further, these closely spaced spikelets occur singly or in pairs; there is no pedicellate branch development such as is found responsible for creation of thickened portions of the central spike of Branched-silkless.

The ear of Club generally matures a week later than the tassel. Its silks are profuse, and there are 4–6 silks per spikelet, each from a rudimentary pistil—a condition also found in ears of Tassel-seed 8. However, Club ears are fasciated, the branching strongly resembling a type listed by Kempton (1923) as Bearsfoot (see his fig. 1 for a clear illustration). It is apparently caused by one or more incomplete divisions of the growing point when the ear is partly formed, followed by simultaneous development of each new point into a more or less independent ear tip. The upper half of such an ear is generally hollow, and no spikelets are formed on the inside walls.

13. *Vestigial glume (Vg)* (pl. 28, fig. 1).—

First reported by Sprague (1939), Vestigial glume was found to be a dominant mutation on Chromosome 1. It is easily noted in the tassel, where the hyaline outer glumes range from awl-shaped vestiges to nearly one-third normal length. Sprague pointed out that "flowering glumes" (lemmas) and "palets" (paleas) were also reduced in size, with the result that the stamens were nearly completely exposed. In our material, as in his, anthers generally dried up before dehiscence, but occasionally a plant shed viable pollen. Many specimens in our stock had sterile areas (i.e., no stamens were formed) at tips of branches and central spikes, in some cases involving the outer sixth of all branches. Generally, over-all tassel size was smaller and tassel construction, as exemplified by thickness of central culm and branches, was lighter than in normal sibs.

The ear of Vg is easily recognized, as Sprague pointed out, after removal of kernels. There are no chaffy upper and lower glumes, paleas or lemmas present, only short pedestals, each with a low, hard ridge on both upper and lower sides. Above each spikelet pair, in an adaxial position, is a cupule with somewhat reduced rachis-flaps (Lenz, 1948).

14. *Tunicate (Tu)* (pl. 22, fig. 2).—

According to Collins (1917a), this mutant has been reported from several sources and its origin is not known. Recently, it has been cited in connection with theories of maize origin (Mangelsdorf, 1948; Mangelsdorf and Smith, 1949). Cutler (1944) suggested that its widespread occurrence among Indian tribes was because of mystical significance attached to it. Emerson *et al* (1935) listed the character as occurring on Chromosome 4.

Tassels of heterozygous Tunicate plants have normal measurements in all visible parts except the glumes. The glumes are one-fifth to one-fourth longer than those on Standard tassels and enclose paleas and lemmas similarly elongated. The stamen length being normal, the anthers, especially in the central spike, are not fully exserted and therefore are not pendant at anthesis. Pollen is shed abundantly.

Ears of heterozygous Tunicate plants are easily classified. Collins (1917a, b) stated that "the glumes of the female inflorescence, or ear, are developed so that each seed [fruit] is entirely enclosed." Emerson *et al* (1935) likewise attributed

these covers to glumes. In our stock, paleas and lemmas were also elongated, and in many basal spikelets, paleas and lemmas of both upper and lower florets were noted. No fruit occurred in these lower florets, however, and regular rowing was externally apparent. The rachis of a Tunicate cob is rather flexible. Cupule development adaxial to each spikelet pair was not excessive in comparison with Standards; but in the Tunicate ear of Guarani maize sent to the senior author by Dr. P. C. Mangelsdorf, the cupules are much more apparent than is normally the case.

Homozygous Tunicate plants, according to Emerson *et al* (1935), are usually female-sterile. No homozygous plants were available in our collection.

An allele of Tunicate, tu^h, was reported by Mangelsdorf (1948) as being present in *Maiz chapolote*. How this allele would behave with our Standards as background was not determined.

15. *Ramosa 1 (ra_1)* (pl. 29, fig. 1).—

This form was originally described by Gernert (1912) under the name of *Zea ramosa,* and was listed by Emerson *et al* (1935) as Ramosa-ear 1, located on Chromosome 7. Gernert's description of the tassel was brief. In his stocks, tassels were slightly smaller than normal, invariably much branched and cone-shaped. Collins (1917a, b) noted that branches were much more numerous than normal. Kempton (1921) reported 400 as an extreme number; the branches gradually decreased in size upward, the transition from branches to pairs of spikelets being imperceptible. A short central spike was characteristic in our specimens—a fact which Kempton had likewise noted in his plants but which Collins did not mention. It was not possible, according to Collins, to distinguish between plants heterozygous for Ramosa 1 and normals. However, in our material, it was quite simple to separate them; in five F_1 families of Ramosa 1 $\times$ Standard, four with 10 plants and one with 9 plants, separation was easily made into 24 normal and 25 heterozygous individuals. Resemblance of tassels of homozygous Ramosa 1 plants to grass panicles is striking (Kempton's plate 13 is typical). Tassels of plants heterozygous for this character were intermediate between a pyramidal paniculate tassel and a normal one, identical to one figured by Kempton in his plate 14.

The ear of Ramosa 1 was described by Gernert as being much branched, without male florets, covered with husks, and composed of a mass of kernels borne on numerous irregular branches. His description applies to our specimens as well, except for two other points: (1) branches on a Ramosa 1 ear are about as numerous and have much the same irregular whorled arrangement as do those of the tassel; (2) there are no adaxial cupules at the junctions of ear branches and central culm. Cupules were present, however, adaxial to each spikelet pair of the branches. No other ear among the mutants in this collection is so organized. It was also a common occurrence for tips of those branches originating near the upper part of the ear to be sterile.

16. *Ramosa 2 (ra_2)* (pl. 29, fig. 2).—

The only published reference to this mutant is found in Emerson *et al* (1935), which simply listed Ramosa 2 as being located on Chromosome 3 and credited its discovery to Brink.

Ramosa 2 has a tassel characterized by stiff upright branches which remain closely appressed to the central culm. The central spike region does not bear short-pedicelled spikelet pairs; instead the spikes are borne on branches which decrease in length from base to apex. There is a pronounced transition from well-developed tassel branches bearing many pairs of spikelets to smaller branches bearing fewer spikelets, some of which appear to occur singly. As one proceeds acropetally, these multi-spikeleted branches are replaced by stalks each bearing only one pair of spikelets which are themselves borne on pedicels longer than normal. In the adaxial area of each of these branches and stalks, a small cupule-like depression in the central culm can be observed which is generally of a different color from the surrounding surface. Although these depressions and short stalks are not confined to Ramosa 2, they are here most common and best developed. The spikelet pairs in proximal areas of well-developed lower branches are likewise stalked and also have abnormally long pedicels, but there is no adaxial depression.

Pollen is shed freely, but much of it remains within the confines of the tassel because close proximity of branches does not allow unrestricted air passage. Each spikelet has two male florets, and each of these has three functional stamens. Tassel-seed 4^a might possibly be confused with Ramosa 2, as its tassels sometimes show the same tendency to have numerous stiff, erect branches and stalked spikelet pairs in the central culm region, with an abundance of pollen produced. It can be separated from Ramosa 2 by the lack of stalked spikelet pairs on lower branches and the fact that each of its branches end in a few sterile undeveloped spikelets.

The ear of Ramosa 2 sometimes ends in a staminate structure looking like a normal central spike. Most commonly, it produces scattered branches on the upper (distal) half of the cob, which in turn bear female spikelets in pairs. These branches are nearly always found in younger ontogenetic stages than the rest of the plant and consequently set seed only rarely. A branch originates by growth of what would normally be the pedicellate spikelet of a pair of kernel-bearing spikelets. No instances were observed in which the sessile spikelet of such a pair formed anything but a normal caryopsis. The spikelet pairs themselves are borne on short stalks; the cupule is bent at nearly right angles, and is adherent half to the stalk and half to the cob. In addition, these stalks are spaced rather widely apart, so that a cob of Ramosa 2 from which the chaff has been removed resembles a similarly treated cob of Coroico maize (Cutler, 1946).

SUMMARY

Morphological studies have been made on tassels and ears of sixteen mutant forms of maize. Four of these forms are reported for the first time, and the others, for which descriptions were either inadequate or non-existent, are here

described. Each genetic form was introduced into a standard background derived from the inbreds *CC5* and *L317*. The mutants studied included nine tassel-seeded forms: ts_1, ts_2, Ts_3, ts_4, $ts_4{}^a$, Ts_5, Ts_6, ts_7 and ts_8. Others studied were Male-sterile *(ms_1)*, Branched-silkless *(bd)*, Club *(club)*, Vestigial glume *(Vg)*, Tunicate *(Tu)*, Ramosa-1 *(ra_1)* and Ramosa-2 *(ra_2)*.

LITERATURE CITED

Alava, Reino O. (1952). Spikelet variation in *Zea Mays* L. Ann. Mo. Bot. Gard. 39:65–96.

Anderson, Edgar (1944a). Homologies of the ear and tassel in *Zea Mays*. Ann. Mo. Bot. Gard. 31:325–344.

———, (1944b). The sources of effective germ-plasm in hybrid maize. *Ibid.* 355–361.

———, (1949). Introgressive hybridization. 109 pp. New York.

———, (1951) The sacred plume. 24 pp. Publ. Pioneer Hi-Bred Corn Co. Des Moines.

———, and W. L. Brown (1952a). The history of the common maize varieties of the United States corn belt. Agric. History 26:2–8.

———, ———, (1952b). Origin of corn belt maize and its genetic significance. In: Heterosis. pp. 124–148. Edited by John W. Gowen. State College, Ia.

Anderson, E. G., A. E. Longley, C. H. Li, and K. L. Retherford (1949). Hereditary effects produced in maize by radiations from the Bikini atomic bomb. I. Studies on seedlings and pollen of exposed generation. Genetics 34:639–646.

Collins, G. N. (1917a). Hybrids of *Zea ramosa* and *Zea tunicata*. Jour. Agric. Res. 9:383–395.

———, (1917b). Hybrids of *Zea tunicata* and *Zea ramosa*. National Acad. Sci. Proc. 3:345–349.

Cutler, H. C. (1944). Medicine men and the preservation of a relict gene in maize. Jour. Hered. 35:291–294.

———, (1946). Races of maize in South America. Harv. Univ. Bot. Mus. Leafl. 12:257–292.

Emerson, R. A. (1920). Heritable characters of maize. II. Pistillate-flowered maize plants. Jour. Hered. 11:65–76.

———, (1932). The present status of maize genetics. Sixth Internat. Cong. Genetics Proc. 1:141–152.

———, G. W. Beadle, and A. C. Fraser (1935). A summary of linkage studies in maize. Cornell Univ. Agric. Exp. Sta. Mem. 180:1–83.

Gernert, W. B. (1912). A new subspecies of *Zea Mays*. Amer. Nat. 46:616–622.

Hayes, H. K., and H. E. Brewbaker (1928). Heritable characters in maize. XXXIII. Sorghum tassel. Jour. Hered. 19:561–567.

Kempton, J. H. (1921). Inheritance of ramose inflorescence in maize. U. S. Dept. Agr. Bull. 971:1–20.

———, (1923). Heritable characters of maize. XIV. Branched ears. Jour. Hered. 14:243–252.

———, (1934). Heritable characters in maize. XLVII. Branched silkless. *Ibid.* 25:29–32.

Lenz, L. W. (1948). Comparative histology of the female inflorescence of *Zea Mays* L. Ann. Mo. Bot. Gard. 35:353–376.

Mangelsdorf, P. C. (1948). The role of pod corn in the origin and evolution of maize. Ann. Mo. Bot. Gard. 35:377–406.

———, and C. E. Smith, Jr. (1949). New archaeological evidence on evolution in maize. Harv. Univ., Bot. Mus. Leafl. 13:213–247.

Nickerson, N. H. (1953). Variation in cob morphology among certain archaeological and ethnological races of maize. Ann. Mo. Bot. Gard. 40:79–111.

———, (1954). Morphological analysis of the maize ear. Am. Jour. Bot. 41:87–92.

Phipps, I. F. (1928). Heritable characters in maize. XXXI. Tassel-seed 4. Jour. Hered. 19:399–404.

Singleton, W. R., and D. F. Jones (1930). Heritable characters in maize. XXXV. Male sterile. Jour. Hered. 21:266–268.

Sprague, G. F. (1939). Heritable characters in maize. L. Vestigal glume. Jour. Hered. 30:143–145.

Weatherwax, Paul (1916). Morphology of the flower of *Zea Mays*. Bull. Torrey Bot. Club 43:127–143.

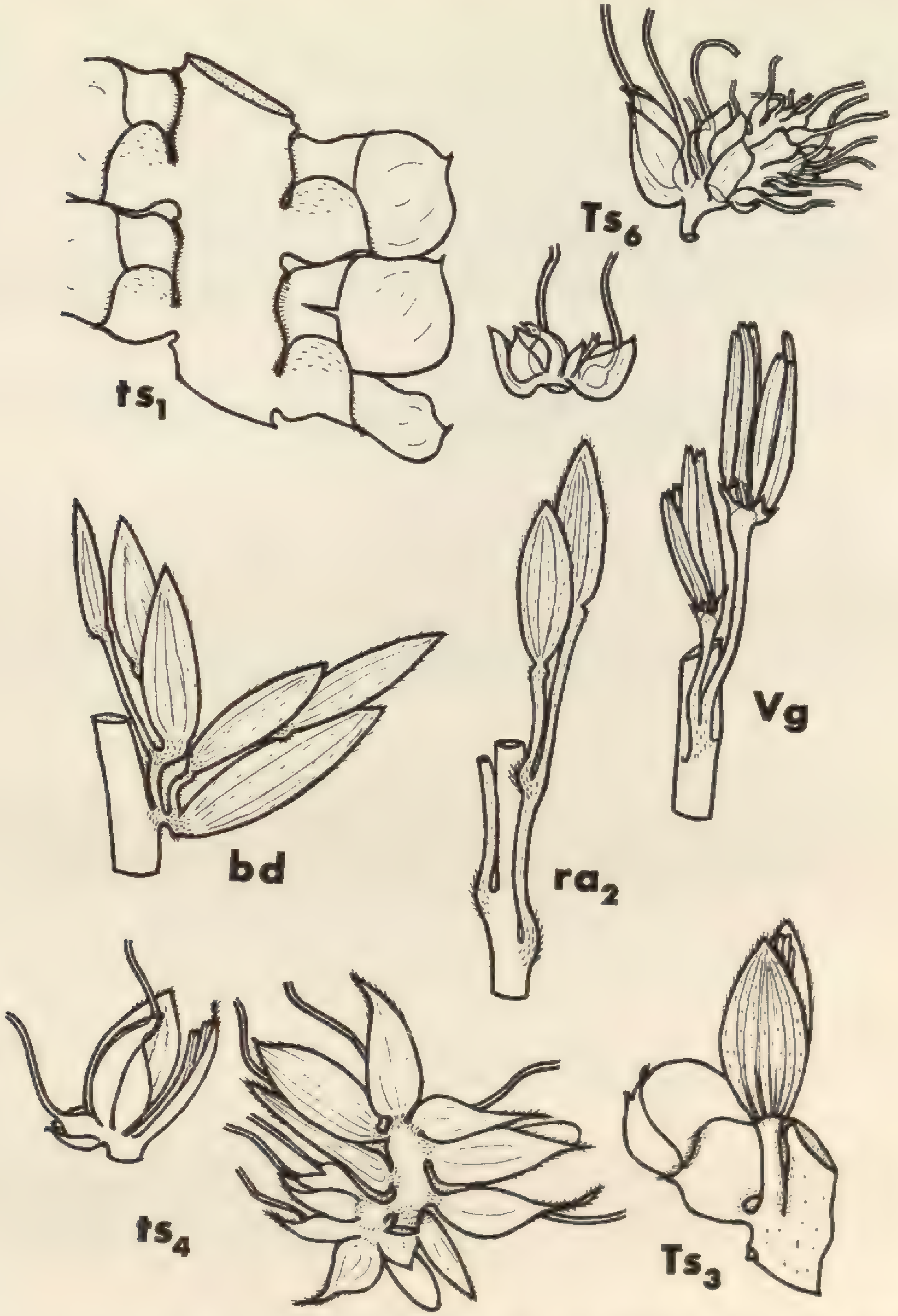


Fig. 2. Drawings to same scale of spikelet pairs found on lowermost primary tassel branches of certain mutants showing characteristic features: *ts*1, adaxial view of thick, ribbon-like branch showing cupules and a developed second floret (silks removed). *Ts*6, pedicellate (right) and sessile (below) spikelets with hyaline awnless glumes; pedicellate spikelet forms numerous naked small pistils. *bd*, both spikelet axes form extra spikelets. *ra*2, an extra internode is found between the primary axis and point of departure of the sessile spikelet. *Vg*, glumes do not develop, so stamens are left naked. *ts*4, sessile spikelet left has one male and two female florets; pedicellate spikelet (right) forms numerous spikelets, with many of the thin glumes ending in soft awn-like tips. *Ts*3, sessile female and pedicellate male in one spikelet pair; pedicellate axis adheres to edge of cupule for part of its length (silks removed).

Fig. 1. Standard Fig. 2. Tunicate (*Tu*)

NICKERSON AND DALE—TASSEL MODIFICATIONS IN ZEA MAYS

Fig. 1. Tassel-seed 1 (ts_1) Fig. 2. Tassel-seed 2 (ts_2)

NICKERSON AND DALE—TASSEL MODIFICATIONS IN *ZEA MAYS*

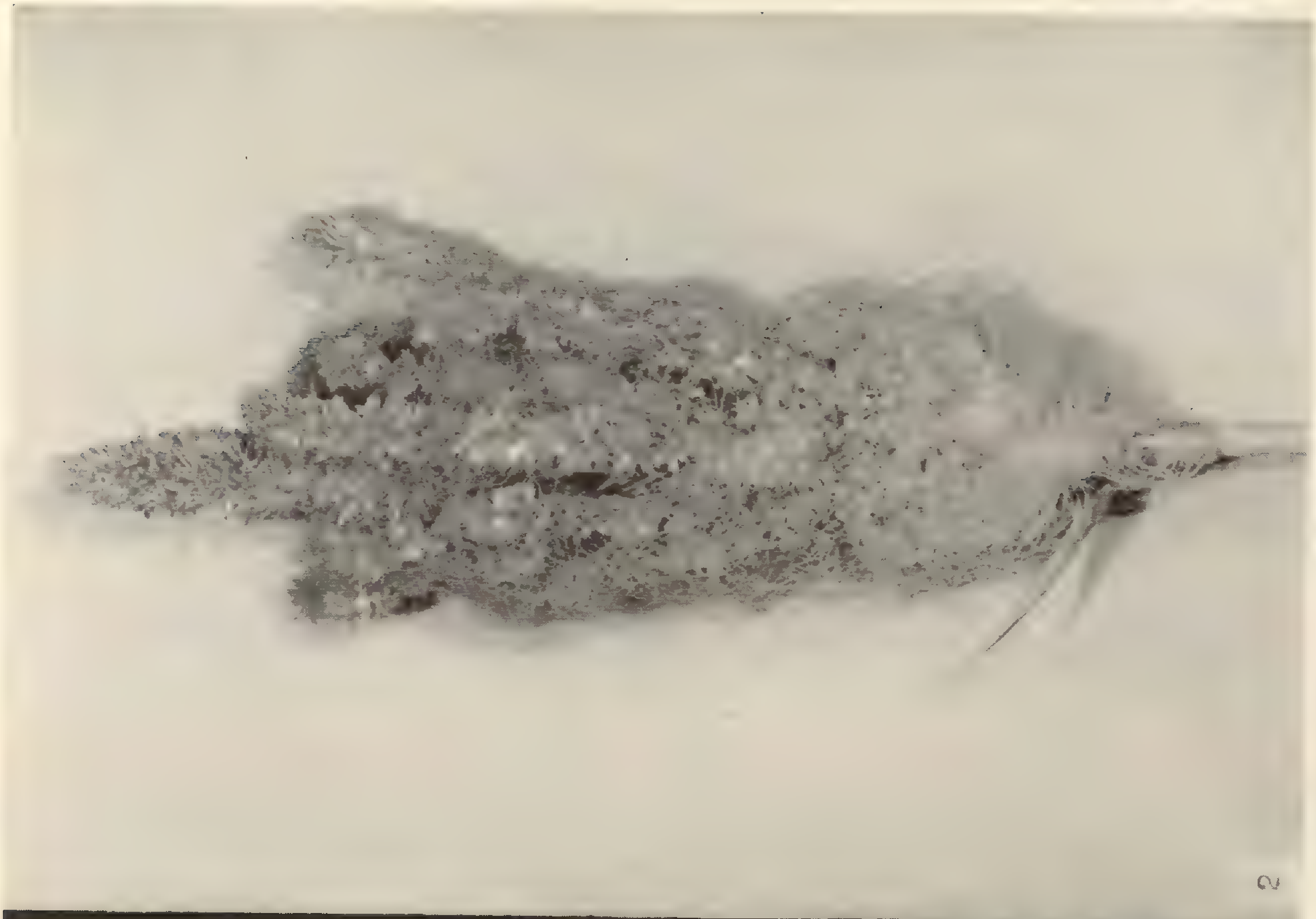


Fig. 1. Tassel-seed 3 (*ts_3*)

Fig. 2. Tassel-seed 4 (*ts_4*)

NICKERSON AND DALE—TASSEL MODIFICATIONS IN *ZEA MAYS*

Fig. 1. Tassel-seed 5 (ts_5)

Fig. 2. Tassel-seed 6 (ts_6)

NICKERSON AND DALE—TASSEL MODIFICATIONS IN *ZEA MAYS*

1 2

Fig. 1. Tassel-seed 7 (ts_7) Fig. 2. Tassel-seed 8 (ts_8)

NICKERSON AND DALE—TASSEL MODIFICATIONS IN *ZEA MAYS*

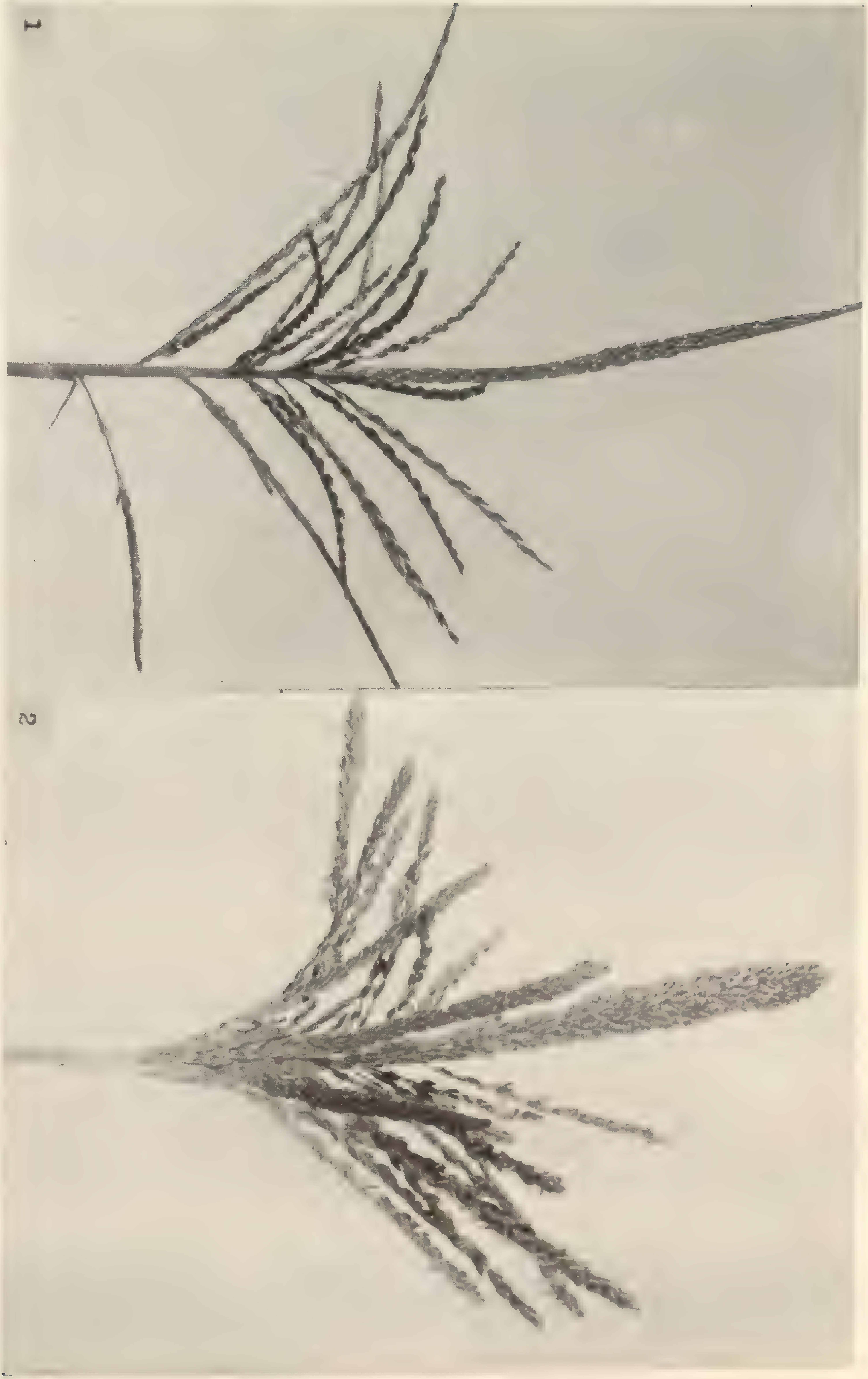


Fig. 1. Male-sterile 1 (ms_1) Fig. 2. Club (*club*)

NICKERSON AND DALE—TASSEL MODIFICATIONS IN ZEA MAYS

Fig. 1. Vestigial glume (*Vg*) Fig. 2. Branched-silkless (*bd*)

NICKERSON AND DALE—TASSEL MODIFICATIONS IN *ZEA MAYS*

Fig. 1. Ramosa 1 (ra_1). Fig. 2. Ramosa 2 (ra_2).

NICKERSON AND DALE—TASSEL MODIFICATIONS IN *ZEA MAYS*

A NEW SPECIES OF *DORYOPTERIS* FROM SURINAM*

KARL U. KRAMER AND ROLLA M. TRYON, JR.

In the course of examination of specimens in the fern collection of the Botanisch Museum en Herbarium, Utrecht, the senior author discovered a specimen of *Doryopteris* that seemed to be different from any species treated in the junior author's revision of the genus[1]. Further examination has proved this to be the case and it is here described as new.

Doryopteris conformis, spec. nov.

Rhizoma modice crassum breviter repens, squamis elongatis angustissimis dense vestitum, partium hyalinarum cellulis latitudine maxime partem quintum longitudinis aequantibus; stipes obscurus laevis vel leviter rugosiusculus, fasciculis vascularibus duobus; lamina fertilis sterili similis coriacea, venatio libera; sterilis suborbicularis—quinquangularis, profunde bipinnatifida; fertilis conformis, profunde bi- vel tripinnatifida; receptaculum intramarginale plus minusve continuum; sporangia breviter pedicellata.

Typus: *Gonggrijp & Stahel (B. W.) 5699;* Surinam: Mt. Hendriktop, alt. 1080 m.; moist, sunny rocks; in Herb. Utrecht.

Rhizome moderately stout, short-creeping; scales of the apex of the rhizome very long and narrow, the cells of the hyaline portions at least five times as long as broad; stipe dark purple to black, naked or slightly scaly at the base, glabrous, smooth or minutely and irregularly roughened, with two vascular bundles at the base, terete; fertile and sterile blades similar, without proliferous buds, coriaceous; sterile leaf about 25 cm. long; blade 7 cm. long, suborbicular-pentagonal, deeply bipinnatifid with about 12 oblong, broadly rounded, entire or partially crenulate ultimate lobes; margin with a pale brown cartilaginous border; venation free; hydathodes prominent on the upper surface; fertile leaf about 25 cm. long; blade about 8 cm. long, suborbicular-pentagonal, deeply bi- to tripinnatifid, with numerous ultimate segments; primary segments broadly decurrent and surcurrent, the bases forming wings along the rachis with symmetrically concave sides; ultimate segments oblong-lanceolate, narrowly rounded, entire; soral lines continuous around the sinuses; sporangia short-stalked, i.e. the stalk somewhat shorter than capsule (which is 340–360 μ long), borne on a more or less continuous vascular commissure; spores subglobose, triplanate, slightly rugose, pale yellow-brown, about 55 μ.

Doryopteris conformis is most closely related to *D. lomariacea* from which it differs in the non-dimorphic fertile and sterile leaves, the segments of the fertile being much broader than in *D. lomariacea,* in the short-stalked sporangia and coriaceous texture of the blades; in *D. lomariacea,* the sporangia are long-stalked and the leaf-tissue is herbaceous.

This species is notable in that it is the only local endemic in the genus outside of southeastern Brazil. However, the Guiana Highlands represent a weak sec-

[1] Tryon, Rolla M. A revision of the genus *Doryopteris.* Contr. Gray Herb. 143:1–80. 1942.

*Issued November 17, 1955.

ondary center for the genus in South America. This is the sixth species known from there, not including the widespread and somewhat doubtfully allied *D. concolor;* a concentration of species exceeded only in the southeastern Brazilian Highlands. It is also significant that all the other five species, *D. lomariacea, sagittifolia, collina, varians,* and *pedata* var. *multipartita* are variously disjunct between southeastern Brazil and the Guiana Highlands. Whether *D. conformis* represents a local offshoot of *D. lomariacea* or whether it was evolved, as all other Guiana species evidently were, in southeastern Brazil and migrated via the Andes to the Guianas, can only be determined if it is eventually discovered in Brazil.

Explanation of Plate

PLATE 30

Fertile and sterile leaf of *Doryopteris conformis,* from type. × ⅔.

KRAMER AND TRYON—*DORYOPTERIS CONFORMIS*

A REVISION OF THE GENUS *CELASTRUS**

DING HOU**

Introduction

There are about 500 species which have been referred in the past to the genus *Celastrus;* of these half are African plants. In 1942 Loesener[1], in a review of the genus for Engler & Prantl's 'Pflanzenfamilien', transferred some of the African species to the genus *Gymnosporia* and some to the allied genus *Maytenus.* In indicating the geographical distribution of *Celastrus* only in Asia, America, Australia, and Madagascar, he seems to have been aware of the fact that the so-called species of *Celastrus* of Africa proper did not truly belong to that genus.

Loesener has expressed the opinion that the confusion regarding species limits in *Celastrus* and the synonymy indicate the need for a more precise study. I have attempted in this treatment to define the generic limits of *Celastrus* and its relationship with other closely related genera, to review and to check all the published binomials of *Celastrus*, and to clarify the complicated synonymy. I have also made a study of the morphological characters and geographical distributions of the different species. I have used the data to separate species or groups of species and to show their inter-relationships (fig. 1). All the "*Celastrus*" species from Africa proper have been excluded in this treatment, as they are referable either to *Gymnosporia* or *Maytenus.* I have tried to delimit definitely the three genera, *Celastrus, Gymnosporia,* and *Maytenus,* which have been very much confused. It is my intention in the near future to make a detailed study of these last two genera. This treatment of *Celastrus* includes two subgenera with thirty-one species and five subspecies.

The generic name comes originally from Theophrastos, who, however, designated with the Greek word κελαστρος (Kelastros) an evergreen tree *(Phillyrea)*, that has nothing to do with our genus[2]. It is feminine in gender as used by Theophrastos, but Linnaeus in adopting it, made it masculine. It has already been pointed out by Airy Shaw[3] that under the International Rules the masculine gender must be retained. Hence, in this treatment, *Celastrus* is treated as masculine and I have standardized all the epithets accordingly.

---

[1]Loesener, Th., in Engler, A. & Prantl, K. Die Natürlichen Pflanzenfamilien 2 Aufl. 20b:131, 134. 1942.

[2]Loes. loc. cit. 2 Aufl. 20B:132. 1942.

[3]Airy Shaw, H. K. in Curtis's Bot. Mag. 158:*t. 9394.* 1935.

---

*An investigation carried out in the Henry Shaw School of Botany of Washington University and submitted as a thesis in partial fulfillment for the requirements for the degree of Doctor of Philosophy.

**Arnold Arboretum of Harvard University, Cambridge, Mass.

Issued November 17, 1955.

History

The genus *Celastrus* was founded and described by Linnaeus[4] in his 'Genera Plantarum' (1737). Later, in his 'Species Plantarum'[5] (1753), he described three American and two South African species. Only one of these, *Celastrus scandens*, is now retained in the genus *Celastrus*.

In 1824, Kunth[6] pointed out that some of the *Celastrus* species, for example, *Celastrus buxifolia* L., *C. montana* Roxb., *C. trigynus* Lam., etc., have peculiar characters and might well constitute a new genus. He gave a detailed description for that group of species, but provided no name for it. In 1834, Wight and Arnott[7] studied the Indian species of *Celastrus*, and, chiefly on the basis of ovule or seed characters, divided the genus into two sections, EUCELASTRUS and GYMNOSPORIA. They gave each section a very concise and clear description. In the section EUCELASTRUS, the ovary is free from the disc, the ovules have a cup-shaped aril at their base, and the seeds are surrounded by an entire fleshy aril. In the section GYMNOSPORIA, which corresponds to Kunth's unnamed genus, the ovary is half-immersed in the disc, the ovules are naked at the base, and the seeds are apparently without an aril or with a very short, imperfect, and membranaceous one at the hilum. In 1862, Bentham and Hooker[8] elevated the section GYMNOSPORIA to the rank of genus. At present the limits of the genus *Celastrus* are identical with those of section EUCELASTRUS of Wight & Arnott.

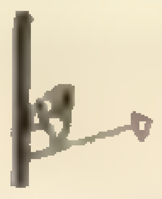
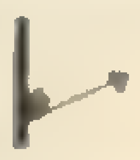
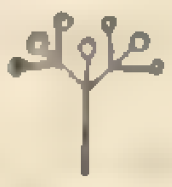
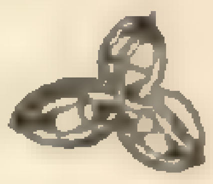
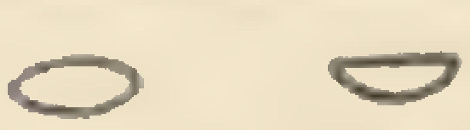
Generic Relationships

Gymnosporia and *Maytenus* are closely related to one another and to *Celastrus*. They often have been confused with *Celastrus* both in the literature and in the herbaria. Exell[9] has pointed out that Loesener's[10] separation of *Gymnosporia* from *Maytenus*, on the presence in the former of either thorns or inflorescences borne on short shoots, appears artificial. He says: "There seems little point in keeping the two genera distinct."

After examining all available specimens of *Celastrus*, *Gymnosporia*, and *Maytenus*, I have concluded that they are distinct though very closely related genera. The following table for distinguishing the three genera is based on a consideration of several characters taken together and not any one single character taken by itself (pl. 31).

---

[4] Linnaeus, C. Genera Plantarum. ed. 1. 59. 1737.
[5] ———. Species Plantarum. ed. 1. 195–197. 1753.
[6] Kunth, C. S. in HBK. Nov. Gen. & Sp. Pl. 7:64. 1824.
[7] Wight, R. & Arnott, G. A. W. Prodr. Fl. Ind. Orient. 152. 1834.
[8] Bentham, G. & Hooker, J. D. Genera Plantarum 1:364. 1862–67.
[9] Exell, A. W., in Kew Bull. 1953:103. 1953.
[10] Loes. loc. cit. 2 Aufl. 20b:109. 1942.

	CELASTRUS	MAYTENUS	GYMNOSPORIA
HABITS	TWINERS	SHRUBS, SMALL TREES OR TREES	SHRUBS OR TREES
PHYLLOTAXY	ALTERNATE	ALTERNATE RARELY OPPOSITE	ALTERNATE
LENTICELS	DISTINCT	OBSCURE	OBSCURE
INFLORESCENCES	DISTINCT DICHASIA OR RARELY SOLITARY	FASCICLED OR RARELY SOLITARY	DISTINCT DICHASIA OR FASCICLED
AXILLARY BUD AND BUD SCALES	DISTINCT 	OBSCURE	OBSCURE 
FLOWERS	POLYGAMOUS RARELY BISEXUAL	BISEXUAL	BISEXUAL
ARTICULATION ON THE PEDICEL	DISTINCT	NONE	DISTINCT 
OVARY AND DISC	OVARY FREE FROM THE DISC, 3-CELLED; DISC USUALLY CUP-SHAPED, RARELY MERELY CONCAVE, MEMBRANOUS, RARELY SUBFLESHY	OVARY SEMI-IMMERSED IN THE DISC, USUALLY 2-CELLED, RARELY 3-CELLED; DISC FLESHY FLAT, RARELY CONCAVE	OVARY SEMI-IMMERSED IN THE DISC, USUALLY 3-CELLED, RARELY 2-CELLED; DISC FLESHY FLAT, RARELY CUP-SHAPED
NO. OF OVULES IN EACH CELL	USUALLY 2 (1 IN CENTRAL AMERICAN SPECIES)	USUALLY 2, RARELY 1	ALWAYS 2
FRUITS: SHAPE	SUBGLOBOSE, FURROWED	ELLIPSOID OR OBOVOID, SMOOTH	SUBGLOBOSE, ANGULAR
FRUITS: NO. OF VALVES	3-VALVED	USUALLY 2-VALVED, RARELY 3-VALVED	USUALLY 3-VALVED, RARELY 2-VALVED 
FRUITS: NO. OF SEEDS	USUALLY 3–6-SEEDED, RARELY 1-SEEDED	USUALLY 1-SEEDED, RARELY 2–4-SEEDED.	USUALLY 3–6-SEEDED
SEEDS: SHAPE	USUALLY OVOID OR ELLIPSOID; ROUND IN CROSS-SECTION	USUALLY OVATE; OVATE OR PLANO-CONVEX IN CROSS-SECTION 	USUALLY OVOID OR ELLIPSOID ROUND IN CROSS-SECTION
SEEDS: ARIL	COMPLETE	COMPLETE OR INCOMPLETE	AT THE BASE OR INCOMPLETE
ARIL OF THE OVULE	CUP-SHAPED ARIL	NONE OR SLIGHTLY AT THE BASE	NONE
DISTRIBUTIONS	CHIEFLY IN ASIA, SOME IN AMERICA & MADAGASCAR	CHIEFLY IN S. & C. AMERICA FEW IN AUSTRALIA AND AFRICA	CHIEFLY IN S. AFRICA AND ASIA FEW IN PACIFIC ILS.

Celastrus Maytenus, and *Gymnosporia* contrasted.

Morphology

HABIT:—Plants of *Celastrus* are scandent, from 1 to 50 meters in height. The branches are hardy, rapid-growing and vigorous. There are very few available records of the diameter of older branches for all the species, but two records of *Celastrus monospermus* show this diameter to be about 10 cm. The branches and branchlets usually are terete, except in *Celastrus angulatus*, and are glabrous except on young branchlets, for example, of *Celastrus hirsutus*.

Most older stems have orbicular to ovate lenticels. In *Celastrus hindsii*, lenticels are usually absent on the current year's growth. They are fine and dense in *Celastrus angulatus* and *C. lenticellatus*, but in *C. hirsutus* and *C. caseariifolius* they are large, elevated, ovate, or orbicular, and are found on the peduncles and pedicels. This feature may well serve as a supporting character to assist in identification of some species.

VEGETATIVE BUDS:—*Celastrus gemmatus* bears axillary buds which are conical and characteristically large. All other species bear small, depressed and ovoid ones. The inflorescences of the species of series AXILLARES (except *Celastrus monospermus*, *C. monospermoides*, and *C. hindsii*) and one species of the subgenus RACEMOCELASTRUS, *C. panamensis*, are associated with accompanying vegetative buds, while the inflorescences of other species are not associated with vegetative buds. The outermost bud scales are usually deciduous, occasionally persistent, falcate, and spiny. These persistent bud scales are called "stipules" by some authors. Usually in *Celastrus aculeatus* and in some specimens of other species, there are four or more outermost bud scales as opposed to the usual two. These are nearly triangular, spiny, and semi-persistent or persistent.

LEAVES:—The leaves are extremely variable, in the same species, and even on the same plant, the result of environmental conditions and the age of the plant. Previous authors mainly have used leaf characters for distinguishing species and varieties in the genus, but such characters are very unreliable. Most of the species are deciduous, but there are evergreen ones, for example, *Celastrus monospermus*, *C. monospermoides*, and *C. hindsii*. The leaf shapes vary from elliptic to oblong, or from broadly ovate to orbicular. The apex and the base vary from acute to obtuse or rotund. The margins usually are serrate, serrulate or subentire; in *Celastrus flagellaris* they appear finely ciliate. In size, the leaves range from 2.0 cm. long and 0.8 cm. wide in *Celastrus punctatus* to 16 cm. long and 16 cm. wide in *C. angulatus*.

Texture usually varies from delicately to firmly membranous. In general, the texture of the leaves in flowering and fruiting stages of the plant is different: for example, in *Celastrus angulatus* the leaves of flowering specimens are delicately membranous, while those on the fruiting specimens are firmly membranous (so-called "coriaceous" of some authors).

The leaves are glabrous or pubescent on the veins below. Sometimes they are pubescent in the juvenile stage and later become glabrous. In *Celastrus hirsutus* there is a dense brownish pubescence on both surfaces.

The leaves of all the species have pinnate and netted veins. The midrib usually is elevated below, and distinctly or slightly elevated above. The primary lateral veins are four to nine pairs on each side of the midrib, arcuate towards the apex. The veinlets though usually visible, are obscure on both surfaces in *Celastrus aculeatus*, and while usually loosely reticulated are densely reticulated in *C. hindsii* and *C. gemmatus*.

The phyllotaxy always is alternate. The petioles are canaliculate, from 0.5 to 3.0 cm. long. In *Celastrus flagellaris* the petiole is half as long as the blade while in the other species it is less than half as long.

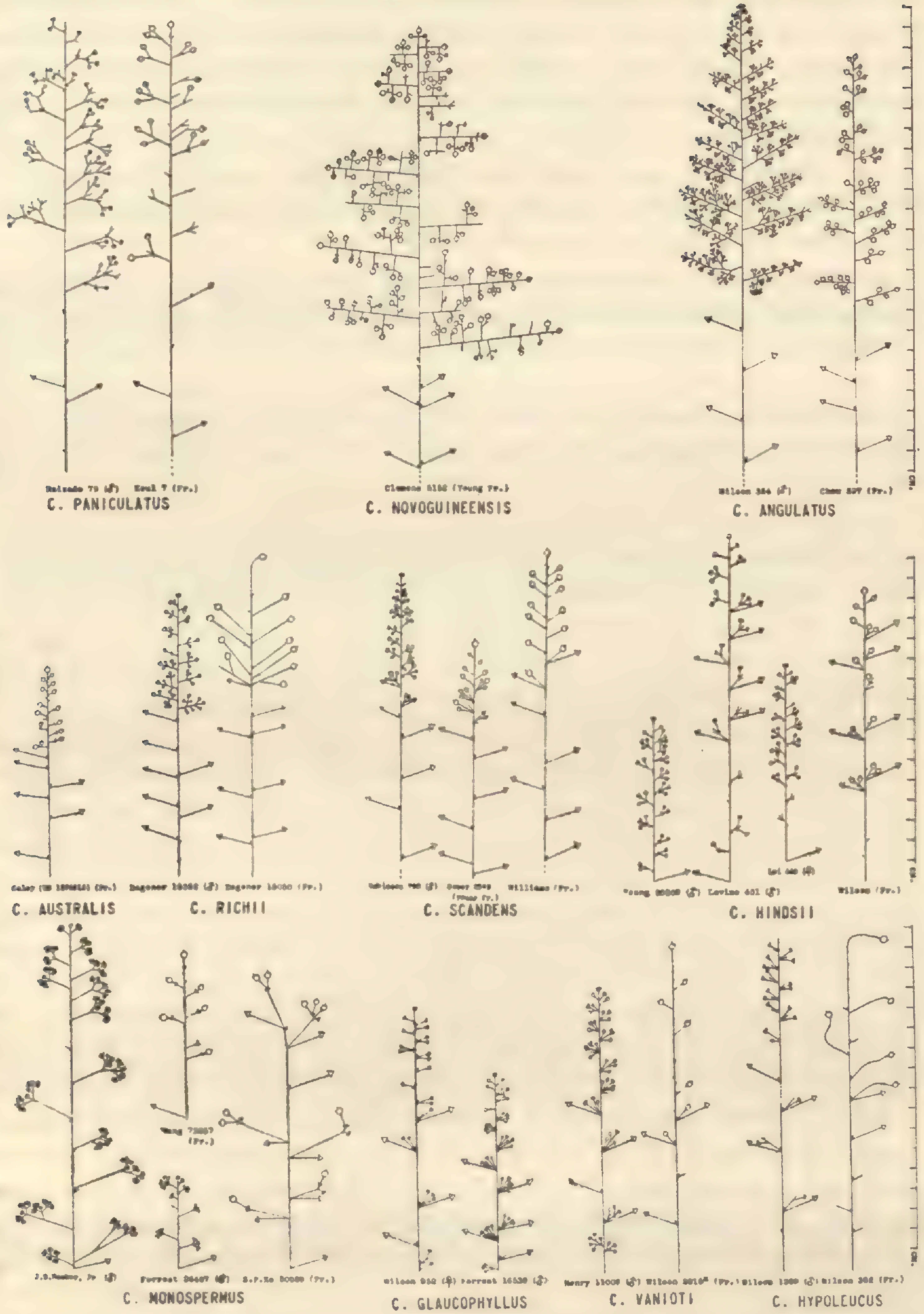
FLORIFEROUS BRANCHES AND INFLORESCENCES:—Diagrams of the *floriferous branches of the current season's* or *year's growth* of most of the species of *Celastrus* have been drawn from herbarium specimens (pls. 32 and 33). These diagrams are arranged according to the sequence of the species in the key, and are not intended to show any evolutionary paths. They will make it convenient for a comparison of the relationships among the species. They also reveal that the male and female plants of the same species have different inflorescence patterns.

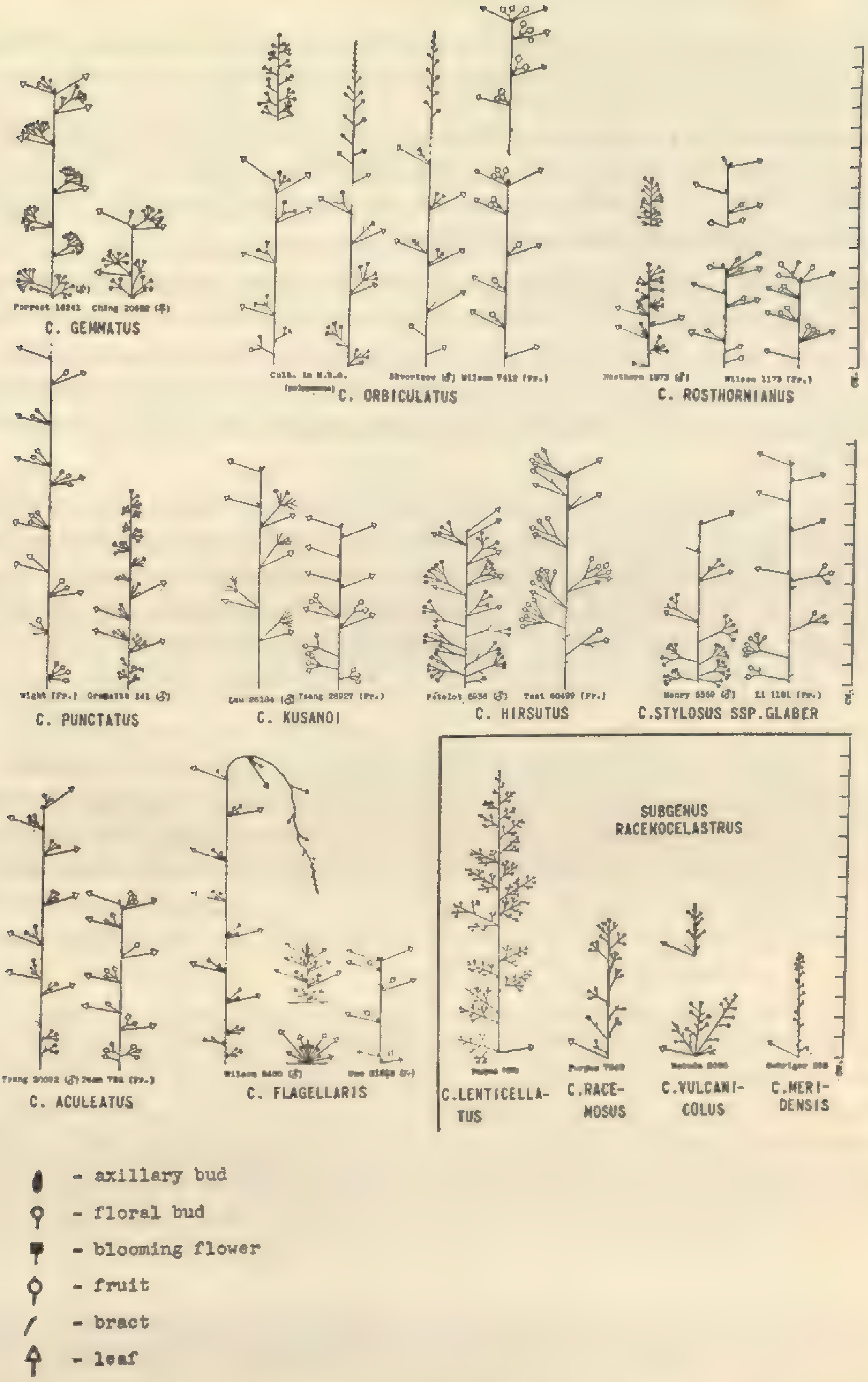
A "flower-cluster" has been thought of as a whole inflorescence or as a part of the inflorescence. Parkin[11] has commented: "It seems futile to quibble over the question whether the inflorescence means the mode of floral branching or the flower-group itself. Custom has sanctioned the latter meaning." I have adopted the customary approach of considering a "flower-group" as an inflorescence only as a matter of convenience in this treatment of the genus *Celastrus*.

Dichasium and Aggregate Dichasium:—The fundamental type of inflorescence in the genus *Celastrus* is an axillary, solitary dichasium. A dichasium in its simplest form consists of three flowers—one terminal and two lateral, the terminal flower blooming first—and is organized as follows: First, there is the primary peduncle terminating in three secondary peduncles to each of which the pedicels of the flowers are articulated. What appears at first to be the entire flower stalk therefore is really a part of the peduncle and the whole pedicel. The dichasium usually is compound, and sometimes the branches are much multiplied to form a terminal paniculiform aggregate dichasium. The aggregate dichasium differs from the thyrse in all axes being determinate and lacking any association with vegetative buds. In the literature the paniculiform floriferous branches are described usually as "panicles."

Each dichasium may or may not be subtended by a foliage leaf or bract, but in the series AXILLARES it is always associated with a dormant bud in the axil of the subtending appendage (pls. 31 and 32). All the species of subgenus RACEMOCELASTRUS have axillary dichasia with or without distinct primary peduncles. The Latin American species of RACEMOCELASTRUS, in addition, usually have dichasia arranged to form a racemiform floriferous branch on the current year's growth (pl. 33). In this case the racemiform branch may be compounded and be located terminally on the branchlets to form a pseudopaniculiform aggregate dichasium

[11] Parkin, J. The evolution of the inflorescence. Jour. Linn. Soc. Bot. 42:512–563. 1914.


C. PANICULATUS
C. NOVOGUINEENSIS
C. ANGULATUS
C. AUSTRALIS
C. RICHII
C. SCANDENS
C. HINDSII
C. MONOSPERMUS
C. GLAUCOPHYLLUS
C. VANIOTI
C. HYPOLEUCUS



Plates 32 and 33. Diagrams of the floriferous branches of current season's or year's growth of *Celastrus* species.

(pl. 33). This type of dichasium differs from the paniculiform aggregate dichasium in series PANICULATI in having a vegetative bud in the axil of each dichasium.

FLOWERS:—The flowers of this genus are small and inconspicuous, usually about 3–5 mm. long. According to the available records the flowers are yellowish-green or white. They are generally dioecious in the subgenus CELASTRUS, and usually bisexual in the subgenus RACEMOCELASTRUS.

Calyx:—The calyx is campanulate and persistent, and sometimes accrescent as in *Celastrus aculeatus.* It always has five short and equal, deltoid, ovate, or oblong lobes which are usually imbricate or in some species rarely open in aestivation. The lobes have simple venation and are glandular-ciliate, slightly erose, or entire; they are glabrous or slightly pubescent on the outer surface, and reflexed or spreading in the fruit.

Petals:—The flowers have five petals which usually are oblong or elliptic, glandular-ciliate to slightly erose, or entire. In *Celastrus paniculatus* the petals have parallel veins while in other species each of the petals has a "costa" and some lateral veins. They are generally glabrous, but in *Celastrus kusanoi* are slightly puberulent on the inner surface. The petals usually are reflexed.

Floral Tube and Disc:—In the flower, there is a cup-shaped or plate-like structure which is usually referred to as the disc. Berkeley[12], who made a morphological and anatomical study of the flower of two species of *Celastrus, C. scandens* and *C. orbiculatus,* on the basis of the behavior of the vascular supply to the flower, interpreted the cup-shaped structure as the floral tube consisting of fused stamen, petal, and sepal bases. He considered the inner layer of the floral tube to be composed of fused basal portions of existing stamens and of stamens no longer present; between the existing stamens, there are small projections of tissue of reduced stamens constituting the "disc" in his sense.

The cup-shaped and membranous "floral tube" is common in most of the species in this genus. It surrounds the pistil but is free from it; on the rim of the tube are attached the free floral parts. A plate-shaped, flat and fleshy "floral tube" is usually present, chiefly in all the species of subgenus RACEMOCELASTRUS and several other species of the subgenus CELASTRUS. The ovary is situated at the center of this type of "tube" and free from it, while all the floral parts are attached on the outer edge of the tube. The two species that Berkeley had studied lacked the flat floral tube, and it is difficult to interpret its origin without morphological and anatomical evidence.

The term disc connotes the "floral tube" of Berkeley, and disc-lobe is equivalent to the "disc" in Berkeley's sense in the present treatment of *Celastrus;* this is just for convenience. The disc-lobe may be distinct or obscure, deltoid, oblong or reniform. Sometimes these are used as supporting characters to identify species.

[12] Berkeley, E. Morphological studies in the Celastraceae. Jour. Elisha Mitchell Scientif. Soc. 70:185–206. 1954.

Fertile and Sterile Stamens:—There are five stamens in the staminate flowers. The stamens depart from the rim of the cup-shaped disc, or are attached immediately beneath the edge of the flat disc. The filaments generally are filiform, fleshy or thin. They are glabrous in all of the species except *Celastrus stylosus* ssp. *stylosus*, *C. aculeatus*, *C. hirsutus*, and *C. kusanoi*, where they are papillose-tuberculate. The filaments usually are longer than the anther, but in *Celastrus novoguineensis* they are shorter. The anthers in the staminate flowers are generally oblong-ovoid, obtuse or cordate, but in some species they are distinctly apiculate, i.e., *Celastrus pringlei*. The sterile stamens in the pistillate flowers are small, short, and about 1 mm. long; the anthers of these are triangular and cordate, and sometimes they may contain sterile pollen grains.

Fertile and Sterile Pistils:—The fertile pistil usually is superior and free from the disc. The ovary usually is subglobose or ovoid, and narrowed into a columnar style. The ovary has three cells. Each cell has two ovules in the species of subgenus CELASTRUS while there is only one ovule per cell in the species of subgenus RACEMOCELASTRUS. The stigma is trilobed or the lobes are obscure. In some species the lobes are further divided in half, for example, *Celastrus orbiculatus*. The lobes usually are filiform and reflexed, but they are tangentially flattened in *Celastrus angulatus*. The sterile pistil in the staminate flowers usually is small and columnar.

Ovules:—The ovules are anatropous and attached at the base of the ovary by a distinct funiculus. The raphe is clearly visible on the seed. In a free-hand section of the ovule the micropyle is sometimes visible towards the base. The ovule has the characteristic cup-shaped aril towards its base, which is a definitive character of this genus.

The embryo is erect, thin-foliate and broadly spatulate[13]. The radicle is cylindric and stalk-like.

FRUITS:—Fruits are subglobose, ovoid, obovoid or cylindric, and are smooth, or rarely angular as in *Celastrus monospermoides*. The bases of the fruits are obtuse or rotund, except in *Celastrus monospermus*, where the base is contracted into a column and is stalk-like. The fruits generally have three cells, but two- or four-celled fruits are occasionally found on some plants. The fruits are three- to six-seeded in most of the species. *Celastrus monospermus*, *C. hindsii*, and *C. monospermoides* have only one developed seed with five undeveloped ovules, while all the species of the subgenus RACEMOCELASTRUS have one developed seed with two undeveloped ovules. The fruit is three-valved, dehiscence being loculicidal. The valves are bright yellow or dark brown, slightly transversely wrinkled on the outside, and spreading or reflexed in dehiscence.

---

[13] Martin, A. C. The comparative internal morphology of seeds. Amer. Midl. Nat. 36:520, *fig. 2*, *pl. 55*. 1946.

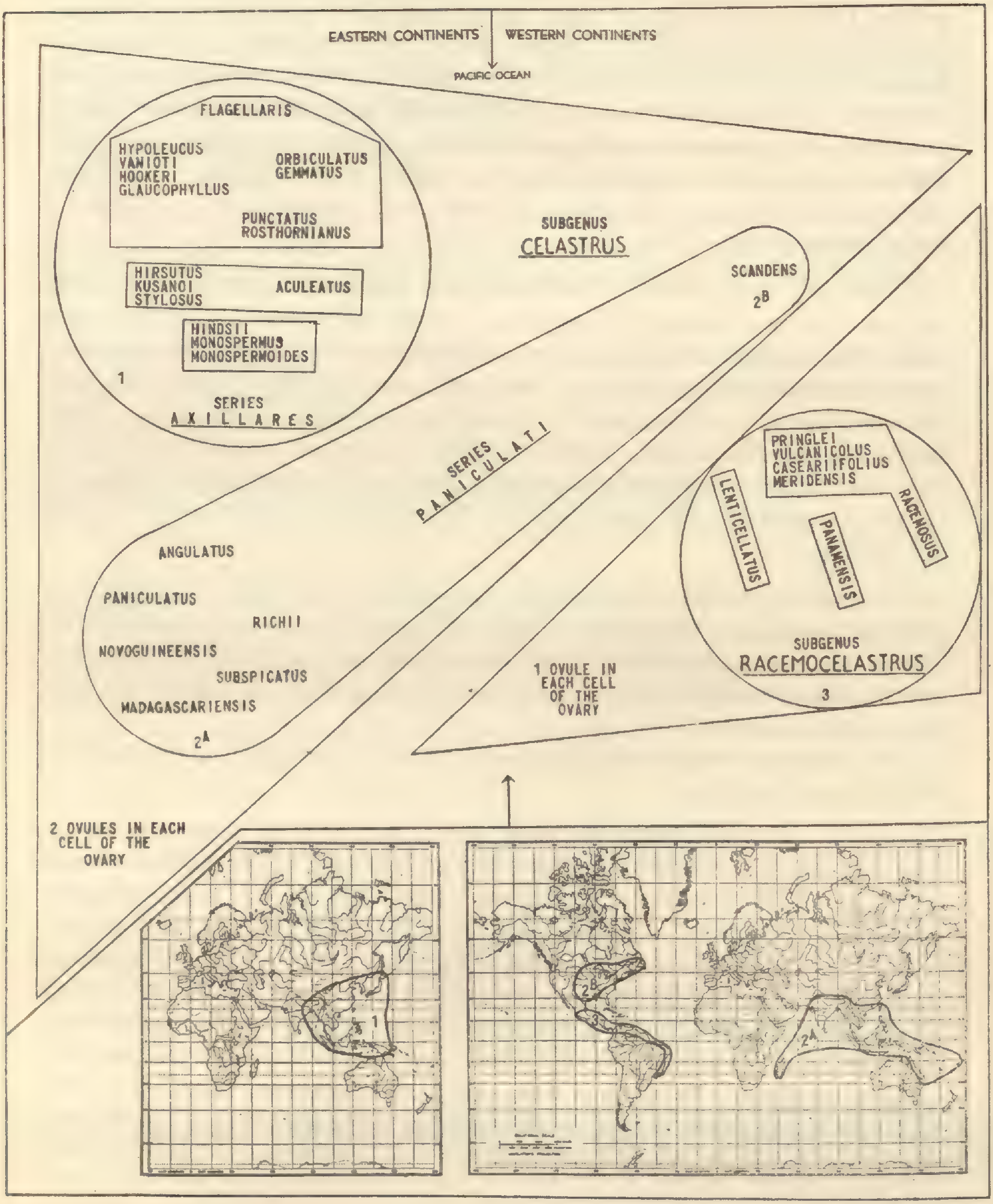


Fig. 1. Chart showing interrelationship of species of *Celastrus* and their geographical distribution.

Harris[14] studied the relationship between the number of flowers formed and the number of fruits maturing per inflorescence in *Celastrus scandens*. He also studied the size of an inflorescence as measured by the number of flowers it produces and the number of seeds per fruit. His conclusion is that there is no correlation between these pairs of characters.

Geographical Distribution

Celastrus is widely distributed in eastern Asia, Oceania, both Americas and Madagascar, between the latitudes of about 40° S. and 47° N. Most of the species are found in the subtropical and tropical zones. From the distribution patterns of the species, it appears that there are two centers of dispersal: Yunnan-Burma-eastern India, and Central America (fig. 2).

In eastern Asia, the species radiate from the Yunnan-Burma-eastern India region. *Celastrus paniculatus,* one of the two most widely distributed species, radiates from that region eastward through Kwangsi, Kwangtung, and Hainan, eastward to Formosa; southward through the Malay Peninsula to Indonesia and then northward to the Philippines, and westward to India and Ceylon. *Celastrus hindsii,* the other widespread species, extends from the center westward to Sikkim; northeastward through Yunnan and Kweichow to Szechuan and Hupeh; eastward to Kwangtung, Fukien, Formosa and Bonin Islands, Japan; and southward through the Malay peninsula to Indonesia. The other species of that area have much more restricted distributions. From the Asiatic center of dispersal, the number of species gradually decreases both northward and southward, as is shown on the distribution map (fig. 2).

In North America there is only one species, *Celastrus scandens.* It is widely distributed forming an ellipse from Quebec southward to Virginia, then westward to Texas and eastern Wyoming. It is closely related to the Asiatic species of the series PANICULATI.

The disjunct distribution and floristic relationship of plants of eastern Asia and eastern North America recently have been interpreted by Li[15]. He says that this familiar disjunct distribution appears to be the remnants of great mesophytic forests that extended over all the northern hemisphere and reached the arctic regions in the Tertiary period. Geological changes have destroyed and changed the floras of many lands so that this mesophytic forest of the Tertiary times in the northern hemisphere survives mainly in eastern Asia and eastern North America.

Berry[16] states: "The genus *Celastrus* Linn. is the largest fossil genus of the family. Though its present center of distribution lies in the upper lands of south-

---

[14] Harris, J. A. Correlation in the inflorescence of *Celastrus scandens.* Mo. Bot. Gard. Ann. Rept. 20:116–122. 1909.

[15] Li, Hui-lin. Floristic relationships between eastern Asia and eastern North America. Trans. Amer. Philos. Soc. 42:371–429. 1952.

[16] Berry, E. W. The Lower Eocene flora of southeastern North America. U. S. Geol. Surv. Prof. Paper 91:105. 1919.

eastern Asia and East Indies, its history shows that the ancestral stock was cosmopolitan and very abundant in the Tertiary of America and Europe. It is highly probable that it originated in America at the dawn of the Upper Cretaceous or somewhat earlier." Croizat[17] says that this view cannot be accepted as it is in conflict with the distribution data, but he cites no alternative center. All that can be said from present distribution patterns is that *Celastrus scandens* is related to the eastern Asiatic center of dispersion rather than to the one in Central America.

It is rather difficult to interpret the relationships of the Central and South American species. Loesener[18] has pointed out that the Latin American species show relationship with tropical Asiatic species. They closely resemble the Asiatic species *Celastrus monospermus*, *C. monospermoides*, and *C. hindsii*, especially in their inflorescence patterns, discs, and one-seeded fruits; but differ in the number of ovules

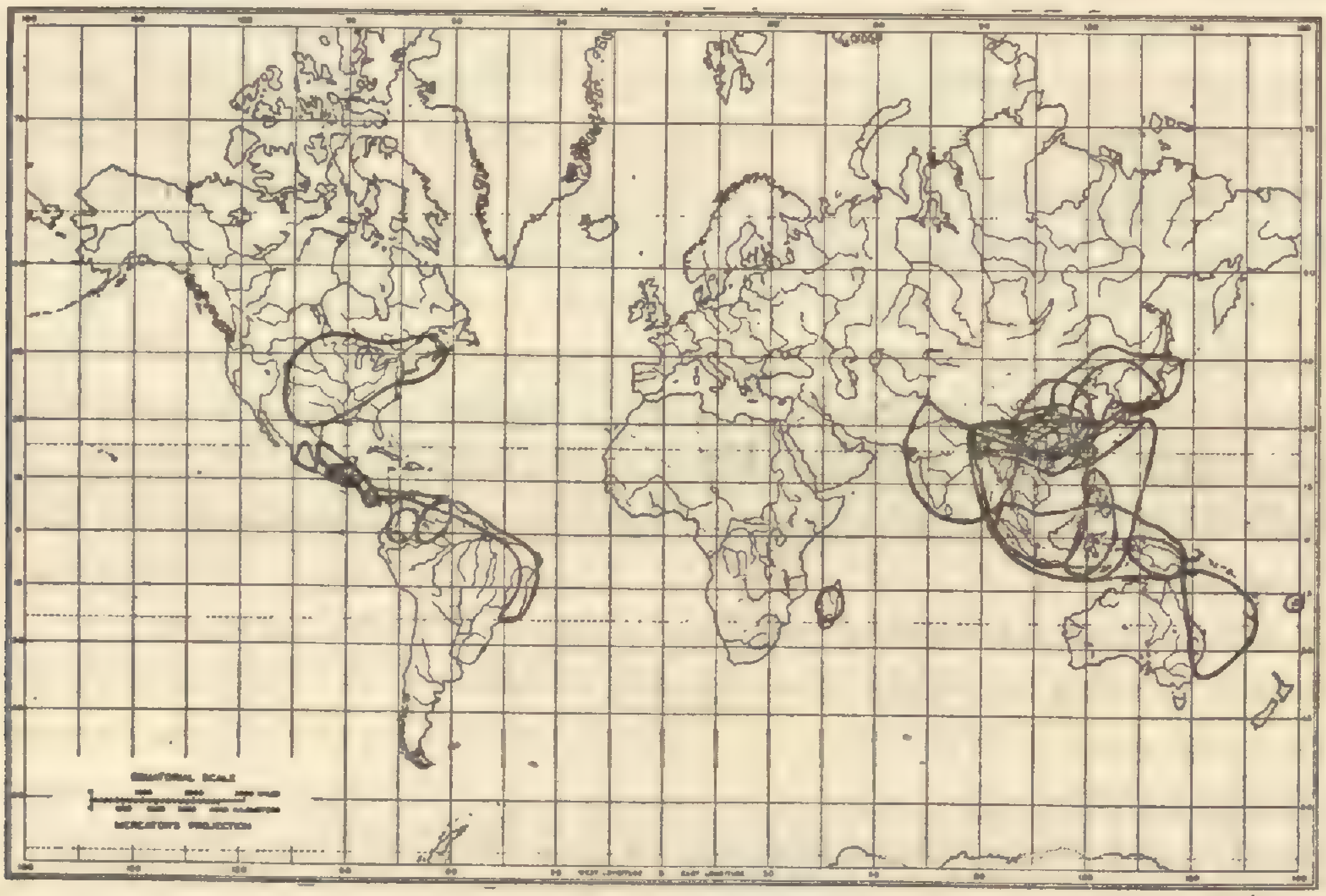


Fig. 2. Distribution patterns of *Celastrus*

All the maps used in this paper are from Goode's Series of Base Maps, University of Chicago Press, except the map of the United States, which was kindly furnished by Dr. Woodson.

in each cell of their ovaries and in their sexuality. In the Central and South American species there is only one ovule in each ovary cell, while in all the other species the ovary cells have two ovules; the Asiatic and North American species are dioecious while the Latin American species are bisexual.

Croizat[19], in his studies of the intercontinental distribution of plants, mentions that some Asiatic genera "run a transpacific channel [sic!]" from the Far East to

[17] Croizat, Leon. Manual of Phytogeography. p. 302. 1952.
[18] Loes. loc. cit. 20b:103. 1942.
[19] Croizat, Leon. loc. cit. pp. 54, 305, and *fig. 16*. 1952.

the New World. He holds the celastraceous genus *Perrottetia* as a perfect example. There are about fifteen species of this genus distributed in Queensland, New Guinea, Moluccas, Celebes, Philippines, northern Borneo, Formosa, central China, Hawaii, Mexico, Colombia, and Venezuela, and every essential station in the "traject [sic!]" is exemplified by one or more species.

An alternative hypothesis is suggested by the fact that the Latin American species of *Celastrus* constitute a distinct subgenus without representatives in the Eastern Hemisphere. These species appear to be closely related to the neighboring genus *Maytenus*, which includes species of both Latin America and Africa, a distributional phenomenon which might be explained upon the hypothesis of trans-Atlantic continental drift. From a rather dogmatic view of phylogeny, one might assume the hermaphroditic flowers of *Maytenus* (as well as of *Gymnosporia*) to be "primitive" from which the bisexual condition general for the Latin American *Celastrus* might be derived. The North American *Celastrus scandens* is closely related to the species of the Eastern Hemisphere rather than to those of the Western Hemisphere, thus suggesting that the North American and Latin American *Celastrus* might have different origins. The two subgenera perhaps therefore can be said to have independent origins.

Hybridization

White and Bowden[20] have reported identical chromosome numbers ($n = 23$) for the American *Celastrus scandens* L. and the Asiatic *C. orbiculatus* Thunb. They were able to hybridize these species with interesting results. The hybrid is less vigorous than the parents and sparingly fertile; the fruits are smaller than those of either parent, and the seeds are not uniform in size. When they back-crossed the hybrid to both parents both the F_2's had leaves closely resembling those of *Celastrus scandens*. The plants resulting from the back-cross to *Celastrus orbiculatus* yielded one-seeded fruits, with only two exceptions among the 475 fruits produced, while the fruits of both parent species contained three to six seeds. Of the plants resulting from those back-crosses, there is no further record available regarding the inflorescences, the sexuality of the flowers, the ovule number in each cell of the ovary, and the sizes and shapes of the seeds.

All the Latin American *Celastrus* species have one-seeded fruits. It would be interesting to learn the chromosome number and morphology in these species. Since the Latin American species are more or less an uniform and isolated group, cytological data might help in relating them to other groups of the genus *Celastrus*.

In *Celastrus*, there appears to be a strong possibility of hybridization taking place in nature in certain localities. For example, *Celastrus vanioti* looks like a hybrid between *Celastrus angulatus* and *C. hypoleucus*. A specimen collected by *Wang 76880* from Yunnan, China, seems a hybrid between *Celastrus hindsii* and *C. monospermus*.

[20] White, O. E., and Bowden, W. N. Oriental and American bittersweet hybrids. Jour. Hered. 38:125–127. 1947.

Economic Uses

There are very few available records of economic uses of *Celastrus*. Two species, *Celastrus scandens* and *C. orbiculatus*, are widely cultivated commercially for their beautiful yellowish fruits which open at maturity and disclose the crimson arillate seeds.

Balfour[21] states that the bark of *Celastrus scandens* has emetic and purgative properties. The seeds of this species are said[22] to be useful pharmaceutically. An oil is extracted from the seeds of *Celastrus paniculatus*, which is described as having a very hot and bitter taste. It *(oleum nigrum)* is useful for burning[23] and has been employed in India successfully in treating beriberi disease[24]. Burkill[25] reports that in Malaya the seeds may be used, externally, in poultices, or in the Philippines, internally, as an anti-rheumatic and as a treatment of paralysis. In Java, the leaves are used in dysentery. In the Philippines, the sap is given as an antidote in opium-poisoning.

Hemsley[26], quoting from A. Henry's record, states that the leaves and roots of *Celastrus latifolius* Hemsl. (= *C. angulatus* Maxim.), when dried in the sun and pounded to a powder, are efficient in killing insects infesting turnips and other vegetables in China.

Acknowledgments

This work was completed under the direction and supervision of Dr. Robert E. Woodson, Jr. I should like to express my deep gratitude for his kind interest, and more particularly for his extraordinary patience and understanding in helping me with the problem of my languages. Also, I cannot be sufficiently grateful to him for the financial assistance he has obtained for me during the course of my study. My thanks are due to Dr. Edgar Anderson, Director of the Missouri Botanical Garden, for facilities extended to me and for useful suggestions. I also acknowledge my gratitude to the Committee on Awards of Fellowships, China Institute in America, for the award of the Frank M. Shu Scientific Fellowship for the years 1952-53-54, enabling me to undertake this study. My sincere appreciation is due to Dr. Rolla M. Tryon, Jr., Dr. Frederick G. Meyer, and Dr. Hui-lin Li for suggestions and criticisms during the course of the investigation. I am also indebted to Miss Nell C. Horner for much constructive criticism. I am happy to acknowledge my indebtedness to the many herbaria and their curators for the loans and facilities extended. Finally, I should like to express my thanks to many other friends who have directly or indirectly aided and encouraged me in the course of this study.

---

[21] Balfour, J. H. Class Book of Botany. p. 794. 1882.
[22] Gray, Asa. The Genera of the Plants of the United States. 2:185. 1849.
[23] Lawson, G. in Trans. Bot. Soc. Edinburgh 6:364. 1860.
[24] Voigt, J. O. Hortus suburbanus Calcuttensis. A Catalogue of the Plants which have been cultivated by the Hon. East India Company's botanical garden, Calcutta, etc. p. 166. 1845.
[25] Burkill, I. H. A Dictionary of the Economic Products of the Malay Peninsula. 1:505. 1935.
[26] Hemsley, W. B. in Jour. Linn. Soc. Bot. 23:124. 1886–88.

Abbreviations

Herbarium specimens used in this study include those of the following herbaria or institutions. The abbreviations for them are taken from Lanjouw & Stafleu's 'Index Herbariorum', part I (Regnum Vegetabile, vol. 2, 2nd. ed., 1954).

A—Arnold Arboretum, Harvard University, Cambridge, Massachusetts.
BLAT—Blatter Herbarium, St. Xavier's College, Bombay, India.
BKL—Herbarium of the Brooklyn Botanic Garden, Brooklyn, New York.
CAL—Indian Botanic Garden, Howrah, Calcutta, India.
F—Chicago Natural History Museum, Chicago, Illinois.
GH—The Gray Herbarium of Harvard University, Cambridge, Massachusetts.
HK—Herbarium, Gardens Department, Hongkong, China.
K—The Herbarium, Royal Botanic Gardens, Kew, England.
L—Rijksherbarium, Leiden, Netherlands.
MICH—University Herbarium, University of Michigan, Ann Arbor, Michigan.
MO—Missouri Botanical Garden, St. Louis, Missouri.
NY—New York Botanical Garden, New York, N. Y.
P—Museum National d'Histoire Naturelle, Laboratoire de Phanérogamie, Paris, France.
PENN—Herbarium of the University of Pennsylvania, Philadelphia, Pennsylvania.
PH—Academy of Natural Sciences, Philadelphia, Pennsylvania.
S—Naturhistoriska Riksmuseum, Botanical Department, Stockholm, Sweden.
SING—Herbarium of the Botanic Gardens, Singapore, Malaya.
TAI—Herbarium, National Taiwan University, Taipei, Taiwan, China.
U—Botanical Museum and Herbarium, Utrecht, Netherlands.
UC—Herbarium of the University of California, Berkeley, California.
UPS—Institute of Systematic Botany, Botanical Garden and Botanical Museum of the University of Uppsala, Uppsala, Sweden.
US—National Museum, Smithsonian Institution, Washington, D. C.

Taxonomy

Celastrus L. Gen. Pl. ed. 1. 59. 1737; Sp. Pl. ed. 1. 196. 1753; Gray, Gen. Pl. U. S. 2:185, *pl. 170.* 1849; Benth. & Hook. Gen. Pl. 1:364. 1862; Loes. in Engl. & Prantl, Nat. Pflanzenfam. 2 Aufl. 20b:131. 1942. (Type species: C. *scandens* L.).

Euonymoides Isnard, ex Medicus, Philos. Bot. 1:173. 1789 *(pro parte)*.
Celastrus § *Eucelastrus* Wight & Arn. Prodr. Fl. Ind. Orient. 158. 1834.
Semarilla Raf. Sylva Tellur. 146. 1838. (T.: S. *bicolor* Raf.).

Scandent shrubs, up to 50 m. tall; branches usually terete, rarely the branchlets angular, usually glabrous, rarely pubescent, scarcely to densely lenticellate. Leaves extremely variable, elliptic to orbicular, serrate or subentire, rarely finely ciliate-serrulate, deciduous, rarely evergreen, alternate, petiolate; stipules small, usually laciniate and deciduous. Inflorescences dichasia, paniculiform to racemiform, solitary, sometimes branched, axillary or terminal, pedunculate or sessile, few- to many-flowered. Flowers small, usually unisexual and dioecious, rarely bisexual, pedicellate and articulate. Calyx campanulate, persistent on the fruits, 5-lobed; petals oblong, obovate-oblong or ovate, glandular-ciliate to erose, or entire, inserted under the disc, alternate with the calyx lobes; disc usually membranous and cup-

shaped, or fleshy and flat, entire or 5-lobed, the lobes alternate with the stamens; stamens 5, the filaments glabrous or papillose-tuberculate, arising from the margin of the disc proper or attached immediately beneath it, the anthers ovoid or oblong-ellipsoid, obtuse or apiculate, dehiscing laterally or extrorsely, dorsifixed, versatile, the thecae separated at the lower half or third; ovary superior, subglobose or ovoid, free from the disc or rarely slightly confluent with it, 3-celled, each 2-ovuled (subgen. CELASTRUS) or 1-ovuled (subgen. RACEMOCELASTRUS), the ovules arising from the base of the ovary, axile, anatropous, with a cup-shaped aril towards its base, sessile or with a short funicle, the style usually columnar, the stigma usually 3-lobed or the lobes obscure, rarely each bifid. Fruit a capsule, usually subglobose, rarely cylindric, tipped by the persistent style, 3-celled, dehiscence loculicidal, 3-valved, the valves terminating in part of the style, 1- to 6-seeded; seeds enclosed in a fleshy crimson aril, the areolae distinct or obscure, the albumen copious, the embryo erect, thin-foliate and broadly spatulate.

KEY TO THE SUBGENERA AND SERIES

A. Flowers unisexual and dioecious; ovary 3-celled, each cell 2-ovuled; fruits 3- to 6-seeded, or in some species 1-seeded with 5 distinctly undeveloped ovules. Asia, Oceania, Madagascar, and North America........Subgen. I. CELASTRUS
- B. Inflorescences usually terminal only, or, if in the axils of the uppermost leaves as well, without accompanying vegetative buds........Ser. 1. PANICULATI
- BB. Inflorescences both terminal and axillary, or axillary only, but the axillary always with accompanying vegetative buds (except in *C. monospermus*, *C. monospermoides*, and *C. hindsii*) ....Ser. 2. AXILLARES

AA. Flowers bisexual; ovary 3-celled, each cell 1-ovuled; fruits 1-seeded with 2 distinctly undeveloped ovules. Central and South America........Subgen. II. RACEMOCELASTRUS

Subgenus I. CELASTRUS

Series 1. PANICULATI Rehd. & Wils. in Sarg. Pl. Wils. 2:354. 1915.

KEY TO THE SPECIES

A. Calyx lobes imbricate, broader than long.
- B. Inflorescences usually at least thrice compound; petioles usually more than 10 mm. long.
  - C. Anthers of the male flowers truncate at the apex, with distinct filaments about 1 mm. long; pistil of the female flower about 2.5 mm. long, the style half as long as the ovary. India, Burma, Siam, Indo-China, China, Malaya, Indonesia, and the Philippines ....1. *C. paniculatus*
  - CC. Anthers of the male flowers apiculate, sessile or subsessile; pistil of the female flower about 1.5 mm. long, the style about one-fourth as long as the ovary. New Guinea ....2. *C. novoguineensis*
- BB. Inflorescences once or twice compound; petiole less than 10 mm. long.
  - D. Anthers of the male flowers not apiculate or obscurely so; stigmata distinctly 3-lobed; disc-lobes truncate; inflorescences usually 3–9 cm. long.
    - E. Fruiting pedicels 1–3 mm. long; leaves firmly membranous. Eastern Australia, Papua, and New Caledonia ....3. *C. subspicatus*
    - EE. Fruiting pedicels 4–12 mm. long; leaves thinly membranous. Fiji........4. *C. richii*
  - DD. Anthers of the male flowers apiculate; stigmata discoid or slightly 3-lobed; disc-lobes cuspidate; inflorescences 1–3 cm. long. Madagascar........5. *C. madagascariensis*

AA. Calyx lobes open, longer than broad.
- F. Young branchlets angular; leaves orbicular or broadly ovate, the petioles of upper leaves usually more than 2 cm. long; inflorescences usually more than 10 cm. long, dense, many-flowered; disc fleshy, flat; fruits subsessile. China ....6. *C. angulatus*

FF. Young branchlets terete; leaves elliptic or broadly elliptic, the petioles of upper leaves usually less than 1.6 cm. long; inflorescences usually less than 8 cm. long, lax, relatively few-flowered; disc membranous, cup-shaped; fruits pedicellate, the pedicels 2–5 mm. long. North America......................7. *C. scandens*

1. CELASTRUS PANICULATUS Willd. Sp. Pl. 1:1125. 1797 (as *paniculata*); Lawson in Hook. Fl. Brit. Ind. 1:617. 1875, ex char.

Scandent shrubs up to 10 m. tall; branches terete, glabrous, brown, the young branchlets terete, usually pubescent, densely lenticellate, the lenticels elliptic, sometimes elevated; axillary buds deltoid to orbicular, about 1.5 mm. long. Leaves elliptic, obovate, suborbicular, broadly ovate, ovate-oblong to oblong, the apex abruptly acute, obtuse or rarely emarginate, the base cuneate, broadly acute to obtuse, the margins serrate or remotely crenate, 5–15 cm. long, 2.5–6.0 cm. wide, firmly membranous, glabrous, sometimes pubescent on the veins below, the primary lateral veins usually 5–7 pairs, elevated on both surfaces, curved toward the apex, the veinlets distinct to slightly elevated below, immersed but visible above; stipules laciniate, about 1 mm. long; petioles 0.5–1.5 cm. long. Inflorescences terminal, paniculiform, thrice- to multi-compound, spreading, usually 5–10 cm. long, rarely up to 20 cm. long, pedunculate, the peduncles glabrous or puberulous, the primary peduncles usually 6–10 mm. long; flowers dioecious, pale or yellowish green, the pedicels about 4–6 mm. long, the articulation at the basal part of the stalk. Male flowers: calyx lobes semi-orbicular, imbricate, ciliate, about 0.7 mm. long and 1.5 mm. wide; petals oblong or obovate-oblong, obtuse, entire, about 3 mm. long and 1.5 mm. wide, with parallel veins; disc cup-shaped, the lobes inconspicuous, slightly triangular; stamens arising from the margin of the disc proper, 3 mm. long, the filaments subulate, flat, glabrous, the anthers ovoid, obtuse, cordate; sterile pistil columnar, about 1.3 mm. long. Female flowers: calyx lobes, petals, and disc as in the male; sterile stamens 1.3 mm. long; pistil 2.5 mm. long, the ovary globose, the style columnar, the stigmata 3-lobed, each deeply bifid, slender. Fruits subglobose, the valves broadly elliptic, about 6–9 mm. long and 5–8 mm. wide, 3- to 6-seeded; seeds ellipsoid, 3.5–5.0 mm. long and 2–5 mm. wide, yellowish-brown, smooth.

Chiefly in thickets, at altitudes from 200 to 1,800 m.; widely distributed in India, Burma, Siam, Indo-China, China, Malaya, Indonesia, and the Philippines; flowering from April to June.

KEY TO THE SUBSPECIES

A. Leaves orbicular to broadly ovate.
  B. Leaves orbicular, suborbicular, or obovate. India, Ceylon, Burma, Indo-China and southwestern China ....1a. ssp. *paniculatus*
  BB. Leaves broadly ovate. Philippines and Indonesia..........1b. ssp. *serratus*
AA. Leaves elliptic to elliptic-oblong. India, Burma, Siam, Malay, Indonesia, Palawan Isl. (Philippines), and China ....1c. ssp. *multiflorus*

1a. CELASTRUS PANICULATUS ssp. PANICULATUS.

Celastrus nutans Roxb. Hort. Beng. 18. 1814, nom. nud.; Fl. Ind., ed. Carey & Wall. 2:390. 1824, ex char.

Celastrus rothiana Roem. & Schult. Syst. 5:423. 1819; DC. Prod. 2:8. 1825, ex char. (T.: *Heyne s. n.*).

Ceanothus paniculatus Heyne ex Roth, Nov. Pl. Sp. 154. 1821, ex char.
Scutia ? paniculata G. Don, Gen. Syst. 2:34. 1832, ex char.
Celastrus pubescens Wall. Cat. 4303. 1831, nom. nud.
Celastrus metzianus Turcz. in Bull. Soc. Nat. Mosc. 31:448. 1858. (T.: *Metz 1549*, GH!).
Celastrus paniculatus var. *pubescens* Kurz ex Prain, in Jour. Asiat. Soc. Bengal 73:196. 1904, nom. nud.
Celastrus paniculatus var. *andamanica* Kurz ex Prain, loc. cit. 73:196. 1904, nom nud.

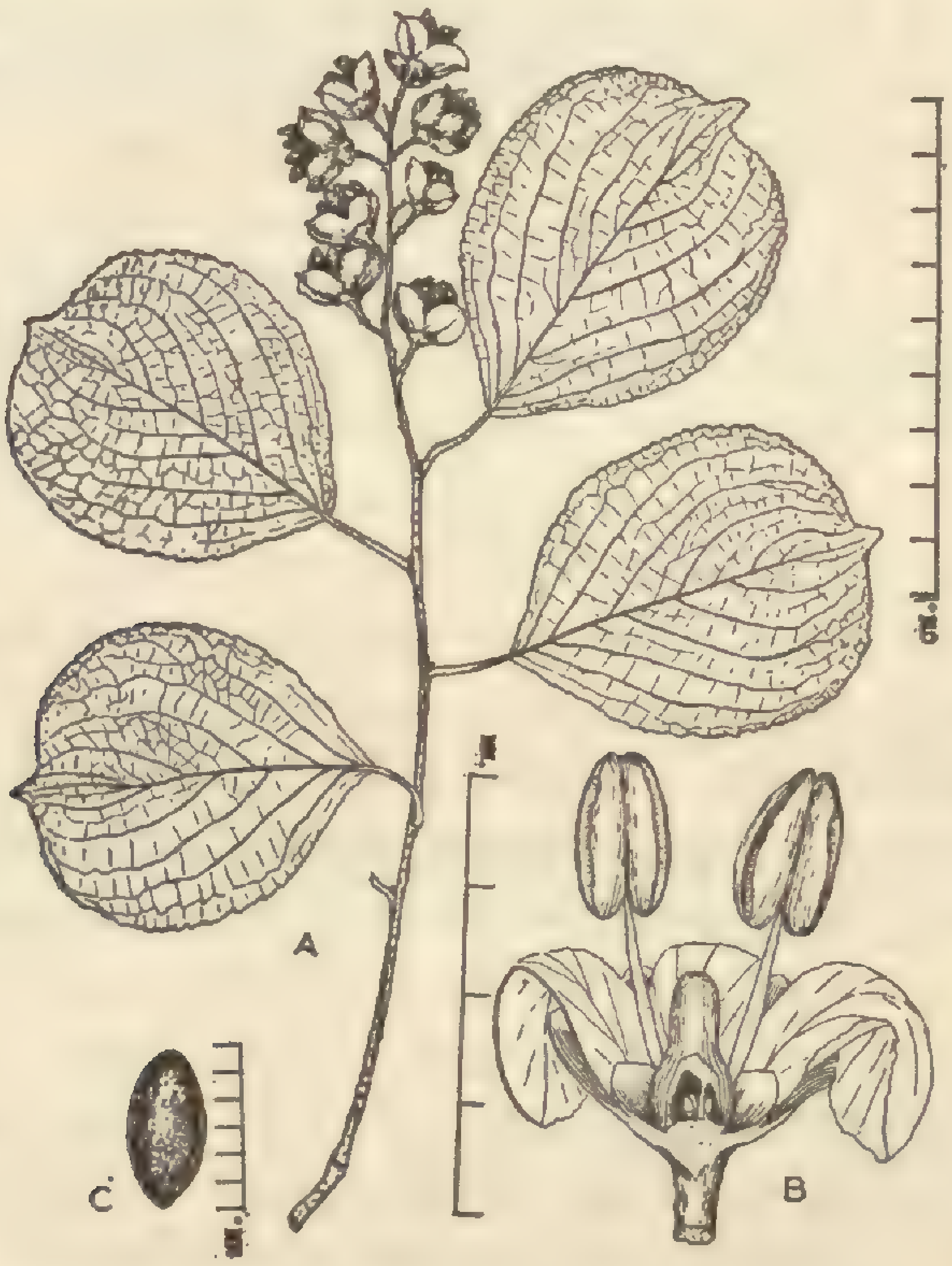


Fig. 3. *Celastrus paniculatus* ssp. *paniculatus*

Burma: Fort Stedman, *Abdul Khalil s. n.*, 1894 (CAL); *Dr. King's collector 454* (CAL), *479* (L); Cokteih Shaub, *Meebold 8055* (S); Maymyo Hill, *Badal Khan 36, 259* (CAL); Maymyo Plateau, *Lace 3130, 3280* (CAL); Pegu, *Eyre s. n.*, 1887 (CAL), *Kurz 1926* (CAL); shan hills: Keloh, *Collett 588* (CAL), Pwehla, *Collett 672* (CAL); Shwebo, *Abdul Huk 62* (CAL); southern shan state: Laikow, *Abdul Khalil s. n.*, 1893 (CAL), *s. n.*, 1894 (CAL), Taungyi, *Abdul Khalil s. n.*, 1893 (CAL), *s. n.*, 1894 (CAL, L, UPS); Yeu, *Cole s. n.*, 1890 (CAL).

Ceylon: Rewamb, *Watson 176* (CAL); without precise locality, *Thwaites 1232* (CAL).

China: yunnan: Che-li, *Wang 75551, 76335* (A); Fo-hai Hsien, *Wang 74570, 74650* (A); Nan-chiao, *Wang 75024* (A); Shung-kiang Hsien, *Wang 72996* (A); Lang-tsang Hsien, *Wang 76644* (A); Szemeo, *Henry 11572* (US).

India: assam: Khasia Hills, 1,000–3,000 ft., *Hooker & Thompson s. n.* (CAL, L, S, U), Duphla Hills, Radhu, Pokri, *Lister s. n.* (CAL); Andamann's, *Dr. King's collector s. n.*, Aug. 2, 1891 (CAL), *Dr. Prain's collector 70, 78* (CAL). bengal: Lower Bengal, *Kurz s. n.* (CAL); Darjelling, Reyang, *Osmaston s. n.*, Nov. 25, 1903 ((CAL), Manbhum, *Campbell s. n.* (CAL); Maymbhing, Baripada, *Hooper 38801* (CAL), Orissa, *Ball s. n.*, April 26, 1896 (CAL); Pachete, *Kurz s. n.* (CAL). bihar state: Chota-Nagpur, Parasnath, *Clarke 24857* (CAL); Chota Nagpur, Palamow, in Kumandi Reserve, *Gamble 8780* (CAL); Golah, Hazaribagh, Chota Nagpur, *Prain s. n.*, Nov. 29, 1891 (CAL); Parasnath, *Kurz s. n.* (CAL); Rajmahal Hills near Sahebganj, *Kurz s. n.*, May 1867 (CAL); Topechana, *Kurz 65* (CAL). bombay state: vic. Concan, *Stocks s. n.* (CAL, L, S. U, UC, UPS); Khandala, *Santapau S. J. 12707* (MO); Poona, Deccan, *Woodrow*

s. n., 1882 (CAL); Dharasu, *Dudgeon & Kenoyer 237* (MO); Bhawani, in montibus Nilagiricis, *Metz 1549* (type of *Celastrus metzianus* Turcz., UPS). HIMALAYA: Bhim-Tal, Kumao, *Strachey & Winterbottom 2* (CAL); Kalidungi, *Thomson 740* (CAL); Lachinwala, *Nai Sanon Samnasena 34* (CAL); Pattludon, *Brandis 2032* (CAL); Raipur, *Clarke 23681*^B (CAL); Kalsi & Asarori, *Amar Nath 24* (A); hills northwest of Kendat, *Prazer 273* (CAL); Madhyapradesh, *King s. n.* (CAL). MADRAS STATE: Ganjam, Pralugaon, Chilka Lake, *Hooper 39537* (CAL); Godairi, Chodavarum, *Ramaswami 1490* (CAL); Naikeneri, Palmaner-chittur, *Fischer 4739* (CAL); Rambba, *Narayanaswami 105* (CAL), MADHYA PRADESH: Gwalior, *Maries 22* (CAL); Khandwa, *Duthie 8211* (CAL). MYSORE: Somanathapur, *Barber 6846* (CAL); Shimoga, *Barber 7018* (CAL); Bettiah, near the Nepal frontier, *Hieronymus 443* (CAL). HYDERABAD: Jalna, Peninsular India, *Rodriguez 2025* (CAL). PUNJAB: Bhadwar, Kangra, *Koelz 4266* (MICH, US), *4377* (MICH, UC, US); Gurdaspur Distr., *Bis Ram 309* (S); Karnal Distr., *Drummond 21651, 21691* (UC); Kasauli Hills, *Drummond 21515* (UC); Kasansi, *Drummond 21516* (UC); Lachhiwala, *Revoti Mohon Mukherjee 32* (US). TRAVANCORE COCHIN STATE: Shencotah to Aryan Karn, *Calder & Ramaswami 654* (CAL); Nokara, *Rama Rao 1588* (CAL). SIKKIM: Garubathen, *Dr. Prain's collector s. n.*, 1,500 ft. alt., 1900 (CAL); Rungit, *Clarke 26330* (CAL); without precise locality, alt. 2,000–4,000 ft., *Hooker s.n.* (CAL, L). RAJASTHAN: Abu, *King s. n.* (CAL), *Stocks 231* (CAL). UTTAR PRADESH: Dehra Dun, *Pradhan 34* (S); Piujour & Dehra Dun, *Anrudh Singh 25* (S), *Vicary (?) 175* (CAL); Upper Gangetic plain, *Harsukh 21400* (UC), Dehra Dun, *Mackinnon s. n.* (CAL); *Singh 43* (UC).

INDO-CHINA: Cambodia, *Pierre 895* (L).

1b. CELASTRUS PANICULATUS ssp. **serratus** (Blanco) Ding Hou, stat. nov.

Diosma serrata Blanco, Fl. Filip. 168. 1837; ed. 2. 119. 1845, ex char.
Celastrus polybotrys Turcz. in Bull. Soc. Nat. Mosc. 31:449. 1858. (T.: *Cuming 1321*).

INDONESIA: CELEBES: Prov. Minahassa, *Koorders 19634β* (L); Makale, *Kjellberg 2907* (S); Paloe, *Curran 3415* (A). JAVA: Prov. Bawean, *Coert 3758* (L); Moenoeng, *de Voogd 682* (A, L); Poeger, Besochi, *Koorders 30178β* (L, UC); Kawi, *Mousset 1111* (L). TIMOR: Nonboumn, *Teysmann 8731* (L); Soë, *de Voogd 2338* (A, L).

PHILIPPINES: BOHOL: *Ramos s. n.*, Aug.-Oct. 1923 (A, UC). LUZON: Prov. Bataan: Lamao, *Cuiran 7499* (SING); Mt. Mariveles, *Whitford 81, 414* (F, US); Prov. Batangas, Taal Volcano, *Gates 7468* (MICH); without precise locality, *Ramos 1813* (L, MO, SING); Prov. Bulacan, *Ramos 346* (A, F, L, MO, US); Cagayan, *Cuming 1324* (L, NY, UPS); Prov. Cavite, *Ramos & Deroy s. n.*, April-May 1915 (L, US); Prov. Nueva Viscaya, *McGregor s. n.*, March-April, 1912 (MO, S); Prov. Pangasinan, *Otanes s. n.*, April-June 1914 (A, SING, US); Rizal, *Ramos 9* (US); *Ahern's collector s. n.*, March 1905 (F, SING, US); Prov. Tayabas, *Alcasid & Edaño 4669* (A); Prov. Zambales, *Fox 4864* (A); without precise locality, *Cuming 1209* (L, MO, UPS). MINDANAO: Dist. Cotabato, *Robinson s. n.*, June 1910 (F); Pagpawan Sitio, Davao Prov., *Edaño s. n.* (L); Pandarochan, *Merrill 944* (US).

1c. CELASTRUS PANICULATUS ssp. **multiflorus** (Roxb.) Ding Hou, stat. nov

Celastrus multiflorus Roxb. Hort. Beng. 18. 1814, nom. nud.; Fl. Ind. ed. Carey & Wall. 2:389, 1824; Fl. Ind. ed. Carey 1:622. 1832, ex char., non Lamarck.
Celastrus dependens Wall. in Roxb. Fl. Ind. ed. Carey & Wall. 2:389. 1824, in obs. *Celastrus multiflorus* Roxb., nom. nud.
Alsodeia glabra Burgdk. in Junghuhn, Pl. Jungh. 122. 1881–85. (T.: *Junghuhn s. n.*, L!).
Celastrus laotica Pitard. Fl. Gén. l'Indo-Chin. 1:891. 1912. (T.: *Pierre 2794*, P!).
Euonymus euphlebiphyllus Hayata, Icon. Pl. Formos. 5:15. 1915, ex char. (T.: *Fujii s.n.*).
Celastrus euphlebiphyllus (Hay.) Makino & Nemoto, Fl. Jap. ed. 2. 597. 1931.
Celastrus euphlebiphyllus (Hay.) Kanehira, Formos. Trees, ed. 2. 383, *f. 340*. 1936, nom. illegit.

Burma: Chin Hills, *Prazer 236* (CAL); Chindwin, near Tummoc, *Prazer 167* (CAL); Kachin Hill, *Shaik Mokim s. n.*, 1897 (CAL); Koni, *Prazer s. n.*, May 1888 (CAL); Luay Wyo, *Rodger 198* (CAL); Maymyo Hill, *Badal Khan 11* (CAL); Myitkyina, *Rogers 864* (CAL); Pinmona, *Abdul Huk s. n.*, Aug. 26, 1890 (CAL); southern Shan State, Taungyi, *Abdul Khalil s. n.*, 1894 (CAL); Tavoy, Oomaigoi, *Shaik Mokim 266* (CAL, L, U); Younghue, *Carter 466* (CAL); without precise locality, *Prazer 54* (CAL), *236* (L).

China: hainan: Ka La, *McClure 9182* (A, MO); Kan-en Hsien, *Lau 3658* (A, S); Ngai Hsien, *Lau 283* (A, MICH, MO, UC, US); Yaichow, *Liang 63042* (A), *How 70573* (A, US). taiwan: Kurau, Kosyun, *Ito s. n.* (photo, A). yunnan: Che-li, *Wang 75551, 77833, 79560* (A); Cheng-kango, Monghui, *Yu 16787* (A); Fo-Hai Hsien, *74966* (A); Jenn-yeh Hsien, *Wang 80588, 80194* (A); Shunning, *Yu 16292* (A); Szemao, *Henry 12122* (MO), *12122*ᴮ, *12122*ᴬ (US), *12572*ᴮ (A), *11972*ᴬ (US), *11993* (A, MO), *11993*ᴬ (US); Ue-lung Shan (Chang-kiang Dist.), *Lau 3191* (S).

India: Khasia, 1,000–3,000 ft. alt., *Hooker & Thompson s. n.* (S).

Indo-China: Prov. Sonla, *4049* (A, UC); Bao-chiang, Prov. Bien-hoa, *Pierre 2794* (lectotype of *Celastrus laotica* Pitard, P); Phuoc-than, *Thorel s. n.*, 1862–66 (paratype of *C. laotica* Pitard, P); Laos, Phon-thane, *Spire 289* (paratype of *C. laotica* Pitard, P).

Indonesia: celebes: Minahassa, *Lam 2466* (L). java: Bantam, *Kuhl & v. Hasselt 18* (L); Madiun, Ngebel, *Koorders 2980B* (L); Parve-sosa, *Backer 37252* (L); Pehalongan, *Koorders 27372B* (L); Soerabaja, *Dorgelo 2290* (L). sumatra: without precise locality, *Junghuhn s. n.* (type of *Alsodeia glabra* Burgdk., L).

Malay Peninsula: Pahang: Kwala Sunbelung, *Mat s. n.*, 1893 (SING); Sea Pardens, Perak, *Ridley s. n.*, 1892 (SING).

Philippines: Palawan, Taytay, *Merrill 9311* (A, F, L, MO, SING, US).

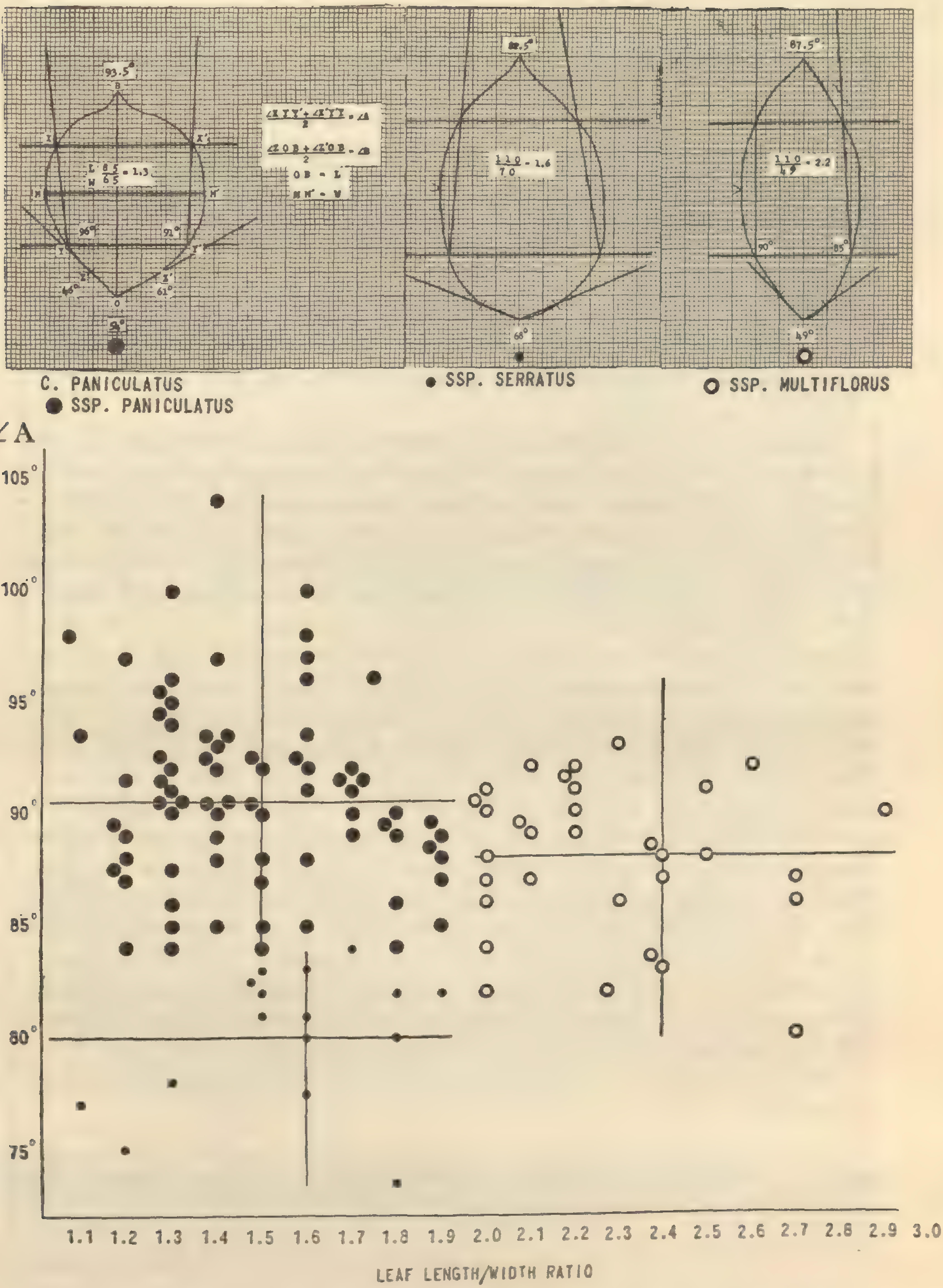
Siam: Bangtapham, *Keith 213* (SING); Bitsenuloke, *Groff 6132* (UC); Kin Sayo, about 120 km. northwest of Kanburi, *Kostermans 1027* (A, L); Wangka, Nei River basin, *Kostermans 441* (L, SING); without precise locality: *Kasin 347* (L), *Sowett 752* (L).

The wide distribution and the variable leaf forms of this species have been the cause of the many synonyms. Because of the inadequacy of flowering material, I selected the middle leaf of a branch of current season's or year's growth for comparative statistical study, following Woodson's[27] method of measuring leaf characters in *Asclepias*. A study of the herbarium material according to the geographical distribution and measurable differences among the populations has demonstrated that this species includes three distinct populations, which I am treating as three subspecies (pl. 34, upper diagram).

Celastrus paniculatus ssp. *paniculatus* has leaves which are usually suborbicular or broadly obovate. It is chiefly distributed in India, but it extends to Burma, Siam, and Yunnan, China. The leaves of ssp. *multiflorus* are oblong, and its distribution is chiefly in Burma and Yunnan, where it overlaps ssp. *paniculatus*. It is also distributed in Hainan, Formosa, Siam, Indo-China, Malaya, Indonesia, and Palawan Isl., in the westernmost Philippines. The leaves of ssp. *serratus* are usually broadly ovate. This subspecies is chiefly distributed in the Philippines, and is less common in Java where it overlaps ssp. *multiflorus*.

---

[27] Woodson, R. E., Jr. Some dynamics of leaf variation in *Asclepias tuberosa*. Ann. Mo. Bot. Gard. 34:353–432. 1947.



Frequency distribution of three subspecies of *Celastrus paniculatus:* large dots, ssp. *paniculatus;* small dots, ssp. *serratus;* circles, ssp. *multiflorus.* Explanation in the text.

I have not seen any specimen of C. *paniculata* collected in Borneo, but I think that it may be found there from the distribution pattern. It is interesting to note from the geographical distribution of these three subspecies that the specimens collected in Palawan Island and Formosa belong to the ssp. *multiflorus* instead of the Philippine ssp. *serratus*. Geologically, Palawan Island and Formosa belong to the Malaysian continent.

The leaves borne on a branch of current season's or year's growth are slightly variable. If a leaf picked at random from a plant of one subspecies is compared with that of another subspecies the same size and form can be found. Following Anderson's[28] method, I have traced the leaf forms on a current season's or year's branch for each subspecies, and the differences in leaf patterns were easily observed.

2. Celastrus novoguineensis Merr. & Perry, in Jour. Arn. Arb. 22:260. 1941. (T.: *Clemens 5152*, A!).

Scandent shrubs; branchlets terete, glabrous, brown to reddish-brown; the lenticels numerous, elliptic, elevated, white; axillary buds conoid, obtuse, about 2 mm. long. Leaves oblong, ovate to elliptic, the apex acute or obtuse, the base obtuse or rotund, the margins minutely and remotely serrulate, 12–16 cm. long, 5.0–7.5 cm. wide, firmly membranous, glabrous, the primary veins 6 pairs, elevated below, distinct, plane or slightly elevated above, the veinlets obscure below, plainly visible above; stipules linear, about 2.5 mm. long; petioles 1.0–1.5 cm. long. Inflorescences terminal, paniculiform, usually thrice compound, about 15–20 cm. long, the floriferous branchlets divaricate, the peduncles glabrous, the primary peduncles about 6–10 mm. long; flowers green, dioecious, the pedicels about 1 mm. long, the articulation varying from the lower to upper half of the stalk. Male flowers: calyx lobes imbricate, subreniform, slightly erose, about 1 mm. long; petals oblong, rotund, subentire, scarious-marginate, about 2.5 mm. long and 1.5 mm. wide, subfleshy, brownish-punctate; disc cup-shaped, membranous, the lobes obscure, truncate or mucronate; stamens subsessile or with very short flat filaments, the anthers narrow-ovoid, obtuse, apiculate, brownish-dotted; sterile pistil 1 mm. long. Female flowers: calyx lobes, petals, and disc as in the male; sterile stamens 1 mm. long; pistil about 1.4 mm. long, the ovary subglobose, wider than long, the style obsolete, the stigmata 3-lobed, each bifid. Fruits subglobose, the valves broadly ovate, about 9–12 mm. long and 7–10 mm. wide, 3- to 6-seeded; seeds ellipsoid, 5–8 mm. long and 2.5–3.5 mm. wide, reddish-brown, smooth.

In thickets, at altitudes 1,220–1,830 m.; New Guinea, flowering from February to September.

New Guinea: northeast new guinea: Morobe-Dist.: Oguawuang (Ogeramnang), *J. & M. S. Clemens 5152* (A, holotype), *5394* (A); Wantoat (Wantot), *Clemens 11073* (A); Yoangen (Yunzaing), *J. & M. S. Clemens 3523, 6606, 7230* (A). papua: Lala River, *Carr 15698* (A). netherlands new guinea: Meervlakte, Motor bivouac, *v. Leeuwen 11098* (L).

---

[28] Anderson, E. Concordant versus discordant variation in relation to introgression. Evolution 5:133–141. 1951.

Map 1. Distribution of species of *Celastrus*, Subgenus CELASTRUS, Series I. PANICULATI.

This is an endemic species of New Guinea. It is distinctive and can be distinguished from other species by the thrice compound aggregate dichasia and main floriferous axis with branchlets extending out at nearly right angles. The stamens in the male flowers usually are sessile or with very short, flat filaments. The pistil in the female flower has a very short style.

3. Celastrus subspicatus Hook. Icon. Pl. 5:*t. 482*. 1842. (T.: *Collector unknown, s. n.*, cultivated at Kew, K!).

Celastrus australis Harv. & Muell. in Trans. Phil. Soc. Vict. 1:41. 1855; Benth. Fl. Austral. 1:398. 1863, ex char. (T.: *Mueller s. n.*).
Celastrus papuana Warb. in Engl. Bot. Jahrb. 13:366. 1891, ex char. (T.: *Warburg s.n.*).
Celastrus paniculatus Willd. var. *Balansae* Loes. in Engl. Bot. Jahrb. 39:160. 1906, ex char. (T.: *Balansa 3029*).

Scandent shrubs; branchlets terete, brownish-pubescent, the lenticels elliptic, distinct, and white; axillary buds deltoid, spiniform, about 1–2 mm. long, the outermost scales acuminate. Leaves elliptic, ovate, suborbiculate, or ovate-lanceolate, the apex acuminate, the base obtuse to acute, the margins subentire to remotely serrulate, 4–12 cm. long, 1–6 cm. wide, membranous, glabrous, the primary lateral veins 5–8 pairs, the veins and veinlets slightly elevated on both surfaces; stipules linear, about 2.5 mm. long; petioles usually 4–7 mm. long. Inflorescences terminal, once compound, rarely twice compound in the male, 2–9 cm. long, occasional in the axils of the uppermost leaves, the peduncles usually brownish-puberulous; flowers white, the pedicels about 3 mm. long, the articulation toward the base of the stalk. Male flowers (young): anthers ovoid, obtuse. Female flowers: calyx lobes imbricate, orbicular, broad, ciliate, about 1 mm. long; petals ovate-oblong, rotund, slightly erose, about 2.5 mm. long and 1.0–1.5 mm. wide; disc cup-shaped, the lobes obscure, truncate; sterile stamens 0.5 mm. long, the filaments very short; pistil ovoid, 2 mm. long, the style short, the stigmata 3-lobed, spread. Fruits subglobose, the valves broadly elliptic, about 5–10 mm. long and 5–8 mm. wide, 3- to 6-seeded; seeds ellipsoid, 5 mm. long and 2.5 mm. wide, reddish-brown, the areolae obscure.

In the thickets; Australia, New Caledonia, and Papua.

Australia: queensland: Cedar Beenleigh, *White s. n.*, May 1920 (SING); head of Burnett R., *Müller s. n.* (GH); Benarkin, *Cameron s. n.*, April 1924 (A); Mt. Glorious, *White 1943* (A); Ilnolan Caves, *Blakely s. n.*, June 1889 (F); Unungar, near Mt. Lindesay, *White 12517* (UC, US); Yarraman Forest Reserve, *Clemens s. n.*, Aug. 5–18, 1944 (UC); without definite locality: *Strathdickie 1124* (GH), *Clemens 43683* (A). new south wales: Success Hill, *Caley s. n.*, 1807 (A, UC, US); Tweed River, *Moore s. n.* (GH); cultivated at Kew, *collector unknown s. n.* (holotype of *Celastrus subspicatus* Hook., K).

New Caledonia: *Balansa 1870* (A); *Deplanch 92* (A).

New Guinea: papua: Kanosia, *Carr 11260* (A, L).

Celastrus subspicatus was published by W. J. Hooker, based on a plant long cultivated in the Royal Botanic Gardens at Kew. Its history and habitat are unknown. In the type specimen, borrowed from Kew Gardens, the leaf forms, texture, short petioles, distinct and elevated lenticels, acuminate outermost

bud scales, and inflorescence patterns are similar to *Celastrus australis*. This similarity leads me to believe that *Celastrus subspicatus* of Kew Gardens was grown from seeds obtained from Australia.

Specimens collected from New Caledonia and lowland Papua, New Guinea, are morphologically similar and geographically related to the Australian ones except in the leaf shape. Meanwhile, not enough specimens are available for a population study to find out whether they really differ from the Australian species and whether they should be put into subspecific or varietal category, so they are treated tentatively as one species.

4. CELASTRUS RICHII A. Gray, in Wilkes U. S. Expl. Exped. (Bot. Phanerogam., pt. 1):289. 1854. (T.: *Wilkes Exped. s. n.*, GH!).

Scandent shrubs; branchlets terete, glabrous, light to dark brown, the lenticels distinct and numerous, white and elliptic, rarely lacking on the young branchlets; axillary buds small, conic, about 1 mm. long. Leaves elliptic, the apex and the base acute, the margins subentire or remotely serrulate, thinly membranous, shining above in dry condition, glabrous, the primary veins 5–7 pairs, elevated on both surfaces, the veinlets distinct on both surfaces, densely reticulate; stipules laciniate, filiform, about 1 mm. long; petioles 2–9 mm. long. Inflorescences terminal, once or twice compound, 2–7 cm. long, the peduncles glabrous, the primary peduncles 3.5–5.5 mm. long; flowers white, the pedicels 1.0–2.5 mm. long, accrescent, up to 15 mm. long on the fruits, the articulation toward the base of the stalk. Male flowers: calyx lobes imbricate, subreniform or semi-orbicular, about 1 mm. long, ciliate; petals oblong, entire, 3 mm. long and 2 mm. wide; disc concave, membranous, the lobes obscure, mucronate, the margins confluent with the base of the filaments; stamens about 2 mm. long, the filaments short, flat, broad at the base, gradually attenuated toward the top, glabrous, the anthers ovoid, slightly cordate and apiculate; sterile pistil conoid, 1.5 mm. long. Female flowers: calyx lobes and petals as in the male; disc cup-shaped, membranous, the lobes subreniform; sterile stamens 0.8 mm. long; pistil 2 mm. long, the ovary subglobose, the style short, the stigmata 3-lobed, each bifid. Fruits subglobose, the valves suborbicular or obovate, about 9 mm. long and 7–8 mm. wide; seeds ellipsoid, about 4.5 mm. long and 3 mm. wide, reddish-brown, distinctly areolate.

In sunny forest; at altitudes 30–900 m.; Fiji Isl.; flowering from December to May.

FIJI: FULANGA: *Smith 1122* (GH, NY, S, UC, US). VITI LEVU: Lautoka, *Greenwood 900* (A); Mba, *Smith 4301* (A, US), *5827, 6085* (A); Tholo, *Degener 14798* (NY, US), *14940, 14973* (A, NY, US), *14978* (A, MICH, NY), *15050, 15315* (A, MICH, NY, S, US); *Gillespie 4182* (GH, NY, UC); Nandi, *Degener 15330* (A, NY, S, US); Ra, *Degener 15352* (A, NY), *15424* (A, MICH, NY, S, US), *15427* (A, NY). WITHOUT PRECISE LOCALITY: *Horne 1135* (GH); *Mrs. Parham 3* (GH); *Wilkes Exped. s. n.*, 1838–42 (GH, holotype).

This is an endemic species of Fiji. Its geographical distribution and accrescent pedicels make this species easily separable from other species. A specimen collected by Degener *(15330)* in an "arid patch of forest along coast" near Nandi has obovoid fruits while all others have subgloboid ones.

5. CELASTRUS MADAGASCARIENSIS Loes. in Notiz. Bot. Gart. Berlin 13:215. 1936, ex char. (T.: *Perrier de la Bathie 2067*).

Scandent shrubs; branches terete, glabrescent, brown, the lenticels elliptic or orbicular, slightly elevated; axillary buds globose to deltoid, about 1 mm. long. Leaves usually elliptic to ovate-oblong, the apex acute to shortly acuminate, the base cuneate or obtuse, the margins crenate-serrulate, 4–7 cm. long, 2.5–3.5 cm. wide, chartaceous to firmly membranous, glabrous, the primary lateral veins 5–7 pairs, elevated on both surfaces, curved toward the apex, the veinlets distinct and slightly elevated on both surfaces; stipules laciniate, about 2 mm. long; petioles 5–11 mm. long. Inflorescences terminal, paniculiform, once compound, 1–3 cm. long, the peduncle puberulous, the primary peduncles 2–3 mm. long; flowers dioecious, the pedicels about 2.5 mm. long, the articulation toward the base of the stalk. Male flowers: calyx lobes imbricate, ovate, obtuse, slightly erose, about 1 mm. long; petals elliptic to ovate, obtuse and subentire, about 3 mm. long and 2 mm. wide; disc membranous, the lobes inconspicuous, cuspidate; stamens arising from the margin of the disc, about 3 mm. long, the filaments shorter than the anthers, glabrous, the anthers ellipsoid, distinctly apiculate; sterile pistil columnar, about 1 mm. long. Female flowers: calyx lobes, petals and disc as in the male; sterile stamens about 1 mm. long; pistil about 2.5 mm. long, the ovary globose, the style shortly columnar, the stigma discoid. Fruit unknown.

In forests; at altitudes 100–1,500 m.; endemic in Madagascar; flowering from October to November.

MADAGASCAR: Valley of the Mandraré, *d'Alleizette 1288* (L); Basaltic near Betafo, *d'Alleizette s. n.*, Sept. 1905 (L).

This species quite clearly belongs to the series PANICULATI by its distinct terminal paniculiform inflorescences. It is closely related to the Australian *Celastrus subspicatus*, rather than to the Asiatic *C. paniculatus*, by its short and once compound inflorescences. It can be distinguished from those two species by its apiculate anthers, cuspidate disc-lobes, and discoid stigma. Loesener has pointed out that the *Celastrus* species of Madagascar enumerated by Drake[29] are *Gymnosporia*. The excellent illustrations reveal that Loesener's view is quite right. Thus *Celastrus madagascariensis* is the only remaining *Celastrus* species described from Madagascar.

---

[29] Drake del Castillo, M. E., in Grandidier's Hist., Phys., Nat. et Pol. Madag. 36 (Hist. Nat. Pl. Atlas 3): *pls. 280, 280a, 280b.* 1896.

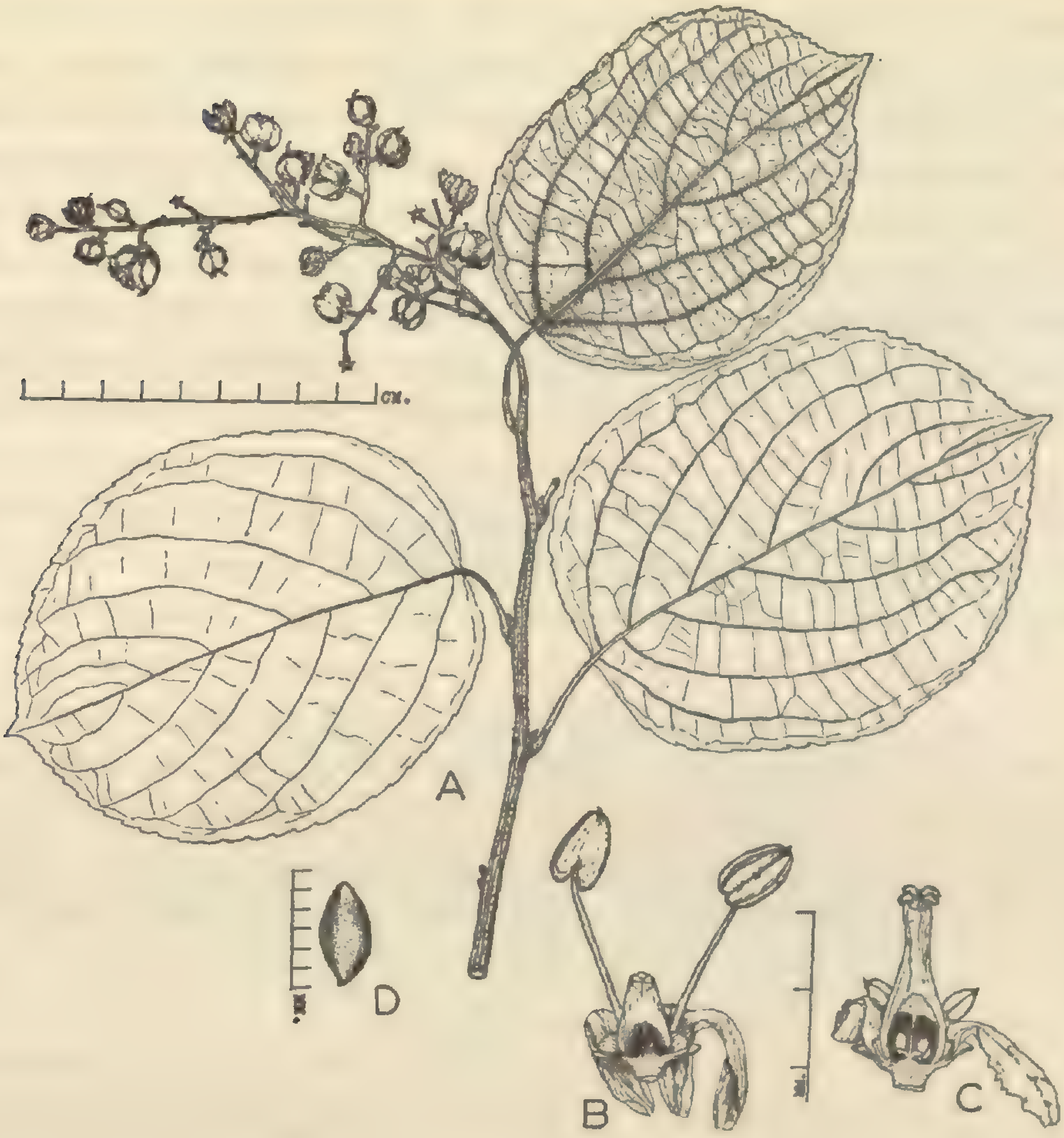


Fig. 4. *Celastrus angulatus* Maxim.

6. Celastrus angulatus Maxim. in Bull. Acad. Sci. St. Pétersb. III, 27:455. 1881 (as *angulata*); in Mél. Biol. Acad. St. Pétersb. 11:199. 1881, ex char. (T.: *Piaseski s. n.*).

Celastrus latifolius Hemsl. in Jour. Linn. Soc. 23:123. 1886; Oliver, in Hook. Icon. Pl. *t. 2206.* 1894, ex char. & ill. (T.: *Henry s. n.*).

Scandent shrubs up to 10 m. tall; branches subterete, the branchlets usually angular, glabrous, both reddish to dark brown, shining, densely lenticellate, the lenticels small, orbicular or ovate, white; axillary buds short-ovoid, about 2–5 mm. long. Leaves broadly elliptic, broadly ovate to suborbicular, the apex abruptly acute, the base obtuse, the margins crenate-serrate, usually 9–16 cm. long, 7–15 cm. wide, firmly membranous, glabrous or pubescent on the veins below, the primary lateral veins usually 6–7 pairs, prominently elevated below, plane or slightly elevated above, the secondary lateral veins slightly elevated below, plane and visible above, nearly parallel to one another; stipules filiform, tufted; petioles 0.6–3.0 cm. long. Inflorescences terminal, densely paniculiform, up to 20 cm. long, the peduncles brownish-puberulous, the primary peduncles 5–8 mm. long; flowers small, greenish-white or yellowish-green, the pedicels obscure, the articula-

tion just beneath the flower. Male flowers: calyx lobes open, ovate or oblong-ovate, obtuse, subentire, about 1.5 mm. long; petals elliptic-oblong, obtuse, ciliate to slightly erose, reflexed, about 2.5 mm. long and 1.2 mm. wide; disc subfleshy, nearly flat, plate-like, the lobes usually depressed-subquadrate; stamens attached just under the margin of the disc, about 3 mm. long, the filaments filiform, glabrous, the anthers ovoid, obtuse, apiculate; sterile pistil ovoid, about 1 mm. long. Female flowers: calyx lobes, petals and disc as in the male; sterile stamens about 1 mm. long; pistil about 3–4 mm. long, the ovary subglobose, the style distinctly columnar, the stigmata 3-lobed, each bifid, recurved. Fruits subglobose, the valves broadly elliptic to suborbicular, about 6–9 mm. long and 5–9 mm. wide, 3- to 6-seeded; seeds ellipsoid, about 3–5 mm. long and 1.5–3.0 mm. wide, brownish-red, shining, the areolae usually obscure, rarely distinct.

In open places, light woods and thickets; at altitudes of 400–3,600 m.; China; flowering from May to June.

CHINA: HONAN: Hia Hsien, *Hers 1831* (A); Hwei Hsien, *Hers 772* (A); Lushih, Hiung-eul Shan, *Hers 861* (A); Sung Hsien, *Hers 1288, 1314* (A); Teng-feng Hsien, *Hers 269* (A); Tsi-yuan Hsien, *Hers 1712* (A); Yungning, *Hers 417* (A). HUPEI: Chang-yang, *Wilson 753A* (A); Enshih Hsien, *Ho-ch'ang Chow 2005* (A, NY); Fang Hsien, *Wilson 364*[a], *753* (A, F, GH, MO, US); Ho-long-teng, *Silvestri 5099* (A); Ichang, *Chun & Chien 8050* (UC), *Henry 2084, 3405, 3883* (GH), *5925* (A, GH, NY), *Wilson 364* (A, F, MO, US); Ma-pan-scian, *Silvestri 1336* (A); Nanto, *Wilson 783* (A); Paokan, *Wilson 467* (A, NY); Patung Hsien, *Ho-ch'ang Chow 495, 597* (A, NY); Sin-yeh-sie, *Chun 3724* (A), *4066* (US); Tzu-kwei Hsien, *Ho-ch'ang Chow 405* (A, NY). KANSU: Tienschui, *Fenzel 2817* (A). KWANGSI: Ch'uan Hsien, *Tsang 27666* (US). KWANGTUNG: Loh-ch'ang, *Tsang 20813* (A, MO, NY, SING, UC), *Tso 21152* (NY). KWEICHOW: Kiangkou, *Steward et al 541* (A, F, NY, S, US); Kweiyang, *Tsiang 8653* (A, NY); Nganping, *Handel-Mazzetti 132* (A); Tsingchen, *Teng 90315* (A); Tsunyi, *Steward et al 97* (A, F, NY, S, US); Tuhshan, *Tsiang 699*[B] (A, NY); Tungtze, *Tsiang 4945, 4970* (A, NY). SHENSI: Hua-Shan, *Hers 3097* (A); Shih Tan, *Hers 2442* (A); Tai-pei Shan, *Purdom 946* (A, US), *Fenzel 738* (A); Tsi-yuan Hsien, *Hers 2670* (A); Tsinling Shan, *Fenzel 678* (A), *Hers 2932, 3010* (A); Tze-wu Hsien, *Meyer 1722* (A). SZECHUAN: Li-fan Hsien, *Wang 21670* (A); Kwang-yun Hsien and vicinity, *Wang 22633* (A); inter Nitou et Hualinpin, *Smith 13448* (UPS); Nan-chuan, *Fang 571* (A), *1362* (A, NY); Wen-chuan, *Wilson 364*[b] (A); without precise locality, *Bock & v. Rosthorn 790* (A). YUNNAN: Eche-hay, *Maire 385* (A); Hsinlung, *Handel-Mazzetti 5692* (A); Tong-tch-ouan, *Maire 22, 393* (A), *6224* (UC).

This species has the largest leaves of any species of *Celastrus*. They reach as much as 16 cm. in length and 15 cm. in width. The characteristic leaves and angular branchlets with dense, small and whitish lenticels make it easily distinguishable from allied species. I saw a living plant of this species cultivated at the Brooklyn Botanic Garden, New York, which has long and dense, paniculiform fruiting branches. During winter and early spring the dehiscing fruits with their crimson arillate seeds present a beautiful and eye-catching sight. This species would make a valuable ornamental plant although it is not now used extensively.

7. CELASTRUS SCANDENS L. Sp. Pl. 196. 1753; Gray, Gen. Pl. U. S. 2:186, *t. 170.* 1849, ex char.

Celastrus bullatus L. Sp. Pl. 196. 1753, ex char.
Euonymoides scandens (L.) Moench, Meth. Pl. 70. 1794.

Scandent shrubs up to 20 m. tall; branches terete, glabrous, castaneous, the lenticels scattered, orbicular or elliptic, the current year's growth yellowish-green, with lenticels lacking or inconspicuous; axillary buds subglobose, about 1.5 mm. long. Leaves elliptic, ovate-elliptic to obovate, the apex acute to short-acuminate, the base rotund to cuneate, the margins crenate-serrulate, incurved, glandular-mucronate, 4–12 cm. long, 2–6 cm. wide, membranous, glabrous; the primary lateral veins 4–6 pairs, distinct and slightly elevated on both surfaces, the veinlets visible on both surfaces; stipules filiform, tufted, about 1.5 mm. long; petioles usually 1.0–2.5 cm. long. Inflorescences terminal, usually once compound, 2–8 cm. long, the peduncles glabrous, the primary peduncles obscure to 5 mm. long; flowers dioecious, green, the pedicels obscure to 3.5 mm. long, the articulation at the upper half of the stalk. Male flowers: calyx lobes open, oblong, rotund, slightly erose, accrescent, about 1 mm. long; petals thin, more or less transparent, rotund, slightly erose, about 4 mm. long, 1.5 mm. wide; disc cup-shaped, the lobes truncate; stamens about 2.5 mm. long, the filaments slender, glabrous, the anthers ovoid, obtuse, apiculate; sterile pistil 1.2 mm. long. Female flowers: calyx lobes, petals, and disc as in the male; sterile stamens about 1 mm. long; pistil flask-shaped, about 3 mm. long, the ovary ellipsoid, the style cylindric, the stigmata 3-lobed, patent. Fruiting inflorescences usually racemiform; fruits subglobose, the valves suborbicular or broadly elliptic, about 8–12 mm. long and 7–10 mm. wide; seeds ellipsoid or slightly plano-convex, obtuse at the base, attenuate toward the apex, about 4.5 mm. long and 2 mm. wide, brown, the areolae obscure.

Roadsides and thickets; lowlands up to 600 m. alt.; North America; flowering from May to June.

CANADA: ONTARIO: Algoma, Bruce, Essex, Frontenac, Glengarry, Leeds, Renfrew, Waterloo, Welland, and York counties. QUEBEC: Brome, Chambly, Chateauguay, Missisquoi, and Pontiac counties.

UNITED STATES: ARKANSAS: Benton County. CONNECTICUT: Litchfield and New Haven counties. DELAWARE: Newcastle County. ILLINOIS: Adams, Champaign, Fulton, Jackson, La Salle, Mason, Peoria, Schuyler, Stark, Vermilion, and Winnebago counties. INDIANA: Floyd, Franklin, Gibson, Jennings, Jefferson, Kosciusko, Marion, Porter, Sullivan, Tipton, and Wells counties. IOWA: Cedar, Clay, Davis, Decatur, Fayette, Hardin, Lee, Story, and Winneshiek counties. KANSAS: Cowley, Douglas, Ellis, Geary, Riley, and Wilson counties. KENTUCKY: Boyd, Fayette, Greenup, Rockcastle, and Warren counties. MAINE: Cumberland, Kennebec, Penobscot, and York counties. MARYLAND: Caroline, Cecil, Harford, Montgomery, and Talbot counties. MASSACHUSETTS: Berkshire, Dukes, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, and Suffolk counties. MICHIGAN: Cheboygan, Emmet, Keweenaw, Menominee, Midland, and Oceana counties. MINNESOTA: Clearwater, Goodhue, Hennepin, Houston, Kandiyohi, Nicollet, and Otter Tail counties. MISSOURI: Atchison, Benton, Chariton, Clay, Cole, Franklin, Hickory, Howell, Iron, Jackson, Jasper, Jefferson, Johnson, Lafayette, Lawrence, Oregon, Ozark, Polk, Ralls, Reynolds, St. Clair, St. Louis, Stoddard, Stone, Taney, Warren, and Wright counties. NEBRASKA: Antelope, Cass, Franklin, Lincoln, Sioux, Thomas, and York counties. NEW HAMPSHIRE: Cheshire, Grafton, Hillsboro, Merrimack, and Rockingham counties. NEW JERSEY: Atlantic, Bergen, Burlington, Camden, Cape May, Cumberland, Gloucester, Hunterdon, Mercer, Middlesex, Monmouth, Ocean, Salem, Somerset, Sussex, and Warren counties. NEW YORK: Albany, Cayuga, Columbia, Dutchess, Orange, Saratoga, Suffolk, St. Lawrence, Tompkins, Ulster, Warren, and Washington counties. NORTH CAROLINA: Buncombe, Iredell, and Mitchell counties. NORTH DAKOTA: Pembina, Ramsey, and Stark

counties. OHIO: Clinton, Cuyahoga, Gallia, Hamilton, Harrison, Jackson, Lawrence, Meigs, Richland, Sciota, and Wood counties. OKLAHOMA: Blaine, Cleveland, Johnston, Kay, Murray, Payne, and Woodward counties. PENNSYLVANIA: Adams, Allegheny, Beaver, Bedford, Berks, Blair, Bucks, Cambria, Carbon, Center, Chester, Clarion, Clearfield, Clinton, Crawford, Cumberland, Dauphin, Delaware, Erie, Fulton, Huntingdon, Indiana, Jefferson, Juniata, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Pike, Schuylkill, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, Wyoming, Westmoreland, and York counties. RHODE ISLAND: Providence County. SOUTH DAKOTA: Brookings, Brule, Grant, Lawrence, and Pennington counties. TENNESSEE: Crockett, Dyer, Gibson, Hamblen, Obion, and White counties. TEXAS: Armstrong, Brewster, Culberson, Jeff Davis, and Sutton counties. VIRGINIA: Bedford, Caroline, Craig, Fauquier, Giles, Roanoke, Shenandoah, Surry, and Isle of Wight counties. VERMONT: Caledonia and Rutland counties. WEST VIRGINIA: Cabell, Marshall, Summers, and Wyoming counties. WISCONSIN: Brown, Buffalo, Door, Iowa, Kenosha, Lafayette, Outagamie, Polk, and Walworth counties. WYOMING: Crook County.

This is the only widely distributed *Celastrus* species in North America. It is also commonly cultivated as an ornamental plant in the United States. This species is easily recognized by its paniculiform inflorescences, open calyx lobes, cup-shaped disc, and especially by the crimson arillate seeds of the opening fruits. Since it is widely distributed and the only commonly known species of *Celastrus* in North America, it will not be confused in the field or in the herbarium. I have seen many specimens of this species all of which are identified correctly. In the present treatment, I have not cited individual collections, but just listed the counties where they are found. All of the collectors and their field numbers can be found in the Index to Exsiccatae at the end of this paper. The variations of morphological characters and geographical distribution of this species have been discussed under the section on general morphology.

Series 2. AXILLARES Rehd. & Wils. in Sarg. Pl. Wils. 2:355. 1915.

Sempervirentes Maxim. ex Rehd. & Wils. in Sarg. Pl. Wils. 2:357. 1915.

KEY TO THE SPECIES

A. Flowering branches terminal or rarely in some species those of the female plants intercalary.
- B. Flowering branches terminal both in male and in female plants; inflorescences both lateral and terminal.
  - C. Evergreen species, the current season's branches usually subtended by foliage leaves; inflorescences usually without accompanying vegetative buds (except some specimens of *Celastrus hindsii*); fruits 1-seeded.
    - D. Young branches with distinct lenticels; flowers numerous in dense umbelliform cymes; discs subfleshy or fleshy, flat; leaves not densely reticulate.
      - E. Fruit conspicuously stipitate; seeds about 15 mm. long, 8 mm. wide. India, Burma, Siam, Indo-China, southwestern and southeastern China. .... 8. *C. monospermus*
      - EE. Fruit not stipitate; seeds about 9 mm. long, 5 mm. wide. Malaya, Indonesia, Philippines and New Guinea .... 9. *C. monospermoides*
    - DD. Young branches rarely with lenticels; flowers few in simple lax cymes, or solitary; discs membranous, cup-shaped; leaves densely reticulate; seeds about 6 mm. long, 5 mm. wide. Southeastern Asia........ 10. *C. hindsii*
  - CC. Deciduous species, the current season's branches not subtended by foliage leaves; inflorescences with accompanying vegetative buds; fruits 3- to 6-seeded.
    - F. Flowers fasciculate or solitary, without distinct peduncles or with very short ones on the terminal inflorescences; calyx lobes imbricate; petals thin and

with distinct venation, 2.5–3.0 mm. long, 1.0–1.5 mm. wide; anthers of the male flowers 0.7–1.0 mm. long; fruiting inflorescences erect, the stalks of fruits not accrescent after anthesis, about 1.0–1.5 cm. long; seeds ellipsoid or ovoid.

G. Terminal inflorescences usually 2–6 cm. long; axillary inflorescences usually several- to many-flowered, fruiting frequently.

H. Veinlets of leaves usually immersed above and elevated beneath; seeds smooth.

I. Anthers of male flowers not apiculate; disc lobes subquadrate to oblong, obtuse or slightly emarginate; leaves usually paler beneath. Southwestern and central China and Indo-China....................11. *C. glaucophyllus*

II. Anthers of male flowers apiculate; disc lobes subreniform, mucronate; leaves concolorous. India, Burma, and China....................12. *C. hookeri*

HH. Veinlets of leaves elevated on both surfaces; seeds highly rugose. India. ....13. *C. membranifolius*

GG. Terminal inflorescences usually 6–18 cm. long, axillary inflorescences few-flowered or suppressed, fruiting infrequently. Southwestern China........14. *C. vanioti*

FF. Flowers in distinctly pedunculate dichasia on the lower two-thirds of the terminal inflorescences; calyx lobes valvate; petals relatively thicker and without distinct venation, about 4 mm. long and 2 mm. wide; anthers of the male flowers 1.5 mm. long; fruiting inflorescences pendulous, the stalks of the fruits accrescent after anthesis, about 2–4 cm. long; seeds slightly lunate. Central and western China ....15. *C. hypoleucus*

BB. Flowering branches terminal in male plants only; inflorescences both lateral and terminal in male plants, lateral only in female plants.

J. Inflorescences dichasial, conspicuously pedunculate; pedicels of fruits green.

K. Vegetative buds relatively large, ovoid, acuminate, 5–11 mm. long; leaves usually broadly ovate, rarely broadly elliptic, the secondary veinlets densely reticulate and elevated; anthers apiculate. China south of the Yangtze River ....16. *C. gemmatus*

KK. Vegetative buds relatively small, conoid, obtuse, 1–3 mm. long; leaves usually broadly elliptic, or broadly obovate to nearly orbicular, the secondary veinlets slightly reticulate and elevated; anthers not apiculate. China north of the Yangtze River, Korea, and Japan....................17. *C. orbiculatus*

JJ. Inflorescences usually fasciculate or subracemiform, usually sessile, rarely very shortly pedunculate; pedicels of fruits brown.

L. Disc lobes broader than long, about one-fourth to one-fifth as long as the disc proper, the articulation usually at the middle or lower half of the stalk. China south of the Yangtze River ....18. *C. rosthornianus*

LL. Disc lobes longer than broad, about half to one-third as long as the disc proper, the articulation usually at the upper third or upper half of the stalk. Southeastern China, Formosa, southern Japan, and Ryukyu Islands ....19. *C. punctatus*

AA. Flowering branches usually distinctly intercalary.

M. Flowers usually in pedunculate cymes, axillary or extra-axillary; leaf margins serrate, the petioles less than half as long as the blades.

N. Seeds slightly lunate, attenuate at both ends; sepals usually erose or glandular; secondary veinlets of leaves conspicuous or elevated on both surfaces.

O. Leaves usually broadly elliptic to orbicular; disc subfleshy, flat or slightly concave.

P. Plants glabrous to slightly pubescent on young flowering branchlets and the leaves beneath; leaves usually suborbicular or orbicular; disc lobes inconspicuous. China: Kwangsi, Kwangtung, Hainan, and Formosa.................... ....20. *C. kusanoi*

PP. Plants densely yellowish brown-pubescent, especially on both surfaces of the leaves; leaves usually broadly ovate or broadly obovate; disc lobes conspicuous, arcuate. Burma, China, and Indo-China....................21. *C. hirsutus*

OO. Leaves usually elliptic or elliptic-oblong; disc membranous, cup-shaped. Eastern India, Indonesia, and China....................22. *C. stylosus*

NN. Seeds semi-annular, obtuse or rounded at both ends; sepals entire; secondary veinlets of leaves obscure on both surfaces. Southeastern China....................23. *C. aculeatus*

MM. Flowers usually solitary and axillary, or rarely fasciculate; leaf margins finely ciliate-serrate, the petioles nearly half as long as the blades. Northeastern and eastern China, Korea, and Japan ....24. *C. flagellaris*

Fig. 5. *Celastrus monospermus* Roxb.

8. Celastrus monospermus Roxb. Hort. Beng. 18. 1814, nom. nud.; Fl. Ind. ed. Carey & Wall. 2:394. 1824, ed. 2, 1:625. 1832 (as *monosperma*). (T.: *Desiloa s. n.* NY!).

Catha benthamii Gardn. & Champ. in Hook. Kew Jour. 1:310. 1849, ex char. (T.: *Champion s. n.*).
Celastrus championii Benth. in Hook. loc. cit. 3:334. 1851, ex char. (based on *Catha benthamii* Gardn. & Champ.).
Celastrus benthamii (Gard. & Champ.) Rehd. & Wils. in Sarg. Pl. Wils. 2:358. 1916.
Celastrus annamensis Tardieu, in Fl. Gen. l'Indo-Chine, Suppl. 1:803, *fig. 98, t. 7.* 1948, ex char. (T.: *Poilane 24300*).

Scandent shrubs up to 10 m. tall; branches terete, smooth, glabrous, reddish or dark brown, the lenticels ovate to orbicular, sparse to dense, sometimes obsolete; axillary buds conoid, about 2 mm. long. Leaves variable, elliptic to oblong or broadly ovate, the apex acute to obtuse, the base cuneate to obtuse, the margins serrate, 7–17 cm. long, 3–9 cm. wide, firmly membranous, glabrous on both surfaces, the primary lateral veins 5–8 pairs, curved toward the apex, elevated below, immersed above, the veinlets distinct, slightly elevated below, immersed and obsolete above; stipules laciniate, about 1 mm. long; petioles 0.5–1.5 cm. long. In-

florescences axillary, simply dichotomous or paniculiform, few and laxly branched, up to 20 cm. long, sometimes longer than the subtending leaf, distinctly pedunculate, the peduncles usually glabrous, rarely pubescent, the primary peduncles 0.5–3.0 cm. long; flowers dioecious, small, greenish-yellow or white, the pedicels obsolete to 4 mm. long, the articulation toward the base of the stalk. Male flowers: calyx lobes imbricate, semi-orbicular, slightly glandular-ciliate, about 1 mm. long; petals shortly oblong, about 2.5 mm. long and 2 mm. wide; disc fleshy, annular, slightly lobed, the lobes entire, subquadrate, broader than long; stamens attached just under the margin of the disc, about 2.7 mm. long, the filaments filiform, the anthers slightly ovoid, pink-punctate, slightly apiculate; sterile pistil 1.3 mm. long, ovoid, slightly immersed in the disc. Female flowers: calyx lobes, petals, and disc as in the male, usually the petals smaller than in the male; sterile stamens about 1 mm. long; pistil about 3 mm. long, the ovary subglobose, narrowed into the style, the stigmata 3-lobed, reflexed. Fruits cylindric, stipitate, 1-seeded, the valves ovate-oblong, about 2 cm. long and 1 cm. wide; seeds cylindric, about 1.5 cm. long and 0.8 cm. wide, smooth, pinkish brown.

Chiefly in thickets, at altitudes from 246 to 1,880 m.; commonly distributed in India, Pakistan, Burma, Indo-China, and China; flowering from March to June.

BURMA: Pang Hoi Phi and Peng Sai, *Rock 2237* (A, US); without precise locality, *Prazer s. n.* (CAL).

CHINA: HAINAN: Bak Sa, *Lau 26285, 26624* (A); Fan Yah, *Chun & Tso 44165* (A, F, NY), *44169* (A, NY, US); Kan-en Hsien, *Lau 3711* (A, S); Po-ting, *How 73564* (A, S); Yaichow, *How & Chun 70273* (A, NY, US), *Liang 62583* (A, NY); without precise locality, *Liang 63419* (A, L, NY, S, US), *65253* (A, NY, S, US), *Wang 35222* (NY), *35893, 36064* (A, NY), *36607* (NY). KWANGSI: Bako Shan, western Poseh, *Ching 7525* (A, UC, US); Me-kon, southern Nanning, *Ching 8433* (A, NY, UC, US); Ping Nam Hsien, *Wang 40415* (A); Shap-man-taai Shan, Shang-sze Hsien, *Tsang 22079* (A, S), *24106, 24188, 24735* (A, MO, NY); Yeo-mar Shan, northern Hin-yen, *Ching 7120* (NY). KWANGTUNG: Kowloon, *Wang 3056* (NY); Lofou Shan, *Ho 60086* (NY), *Ko 50089* (NY), *Tsiang 1705* (A, NY, UC); Lung-tau Shan, near Iu, *Kan-peng To et al 473* (UC); Sin-fung Hsien, *Taam 720* (A); Sunyi, *Ko 51463* (A); Tai-o, *Chun 3107* (NY); Tapu Hsien, *Tsang 21751* (A, NY, S); Wung-yuen Hsien, *Lau 800* (A, NY, SING), *2750* (A); Ying Tak, *Tsang & Wong 2681* (UC), *Tsui 348* (MO, NY). EASTERN TIBET & SOUTH-WESTERN CHINA: without precise locality, *Forrest 26407* (A). YUNNAN: Che-li, *Wang 75920, 78458, 79015, 79459, 79776* (A); Chen Kang, *Yu 17495* (A); Fo-hai, *Wang 73579, 73590, 73825, 73839, 74430, 74907, 77202*ᵃ (A); Jenn-yeh Hsien, *Wang 80312, 80781* (A); Lan-tsang Hsien, *Wang 73415* (A); Lung-ling, *Tsai 55679* (A); Lu-se, *Tsai 56917* (A); Mengtze *Henry 10446* (A, NY), *10955* (A, MO), *11399* (A, MO, NY, US); between Mohei and Maokai, *Rock 2900* (A, UC, US); Nan-chiao, *Wang 75183* (A); between Palut and Nam-dip, on the trail from Raheng to Mesawt, *Rock 1024* (US); Ping-pien Hsien, *Tsai 55076, 55139, 60152, 60459, 61680, 62295* (A); Shweli-Salwin, *Forrest 11874* (UC); Si-chour Hsien, *Feng 11445, 11530, 12469* (A); Sunning, Hila, *Yu 16508* (A); Szemao, *Henry 11972* (A, NY), *11972B* (A, MO, NY), *Rock 2770, 2823* (A, UC, US); Tsing-pian, *Tsai 52477, 52552* (A); Tung-ting, *Feng 13472, 13749* (A); Wen-shan Hsien, *Tsai 51546, 51591, 72857* (A); without precise locality, *Wang & Ying Liu 82917, 82947* (A). HONGKONG: *Chun 40143, 40276* (NY); *Chun 4831* (UC), *4943* (A, UC); *Hom Fung 161* (NY); *Taam 1792* (A, US), *2087* (US); Lanto, *Tsiang 720* (UC); *Wright 9* (L), *92* (GH).

INDIA: ASSAM: Darrang, *Upendranath Kanjilal 3801* (CAL); Jawai, *Dr. King's collector s. n.* (L); Khasi Hills, *Kurz 182* (CAL); Kohima, *Dr. King's collector 178* (U,

UPS); Konoma, *Dr. King's collector 233* (A); Namchung, Luckimpore, *Clarke 37949*B (CAL); Naga Hills, *Jagarmani 499* (A, US); *Dr. King's collector 795* (A, CAL), *1082* (CAL); Silhet (as Sillet), *Desiloa s. n.* (NY, type of *Celastrus monospermus*); *Hooker & Thomson s. n.* (CAL, GH, L, S); Khasia, Liam, *Clarke 45152*B (CAL); without precise locality, *Griffith 666* (CAL). BENGAL: Sinchula, *Biswas 2033* (A, NY); Darjeeling, *Lace 2229* (CAL); Darjeeling, *Anderson 107* (CAL); Wangiet, *Kurz s. n.* (CAL); Runquo Valley, *Anderson 108, 109* (CAL); Sureil, *Darsteri 17* (CAL).

INDO-CHINA: Chapa, Tonkin, *Pételot 3184* (UC), *5931* (A), *6368* (A, NY, US).

PAKISTAN: *Griffith 1992* (CAL, GH, L, NY, S).

This species is distinguished readily by stipitate fruit bases, the one-seeded capsules, the large cylindric seeds, the characteristic fleshy annular disc, and the attachment of the stamens immediately beneath the margin of the disc.

The synonymy of this species is due to the failure, first, of Bentham to appreciate the true nature of Roxburgh's *Celastrus monospermus*, and later, of Gardner and Champion, of Bentham, and still later of Rehder and Wilson to appreciate the variability of that species. My present interpretation is that of Lawson (in Hook. Fl. Brit. Ind. 1:618. 1875).

Generally speaking, plants of Yunnan, Burma, and India have oblong or elliptic-oblong leaves, while those of Kwangtung and Kwangsi have broadly elliptic or broadly ovate leaves. At first I attempted either to maintain these plants as two species or to unite them into one species with two subspecies having differing leaf characters. Since then, I have measured the length and width and angles A (apical) and B (basal)[30] from the different areas, and found that the frequency curves of the ratio of length and width, and the angles A and B overlap. Since leaf shape is an extremely variable character and the floral structures of these plants are so similar, I feel justified in considering them as representing a single species.

9. CELASTRUS MONOSPERMOIDES Loes. in Lorentz, Nova Guinea 8:280. 1910. (T.: *Versteegh 1643*, L!).

Celastrus championii sensu King in Jour. Asiat. Soc. Beng. 65^2:639. (Mat. Fl. Malay Penin. No. 8:353). 1896, as to spec. cited, non Benth.
Celastrus apoensis Elmer, Leafl. Philipp. Bot. 7:2579. 1915. (T.: *Elmer 11411*, A!).
Celastrus malayensis Ridl. in Jour. Roy. Asiat. Soc., Str. Branch 75:18. 1917. (T.: *Ridley 13538*, SING!).

Scandent shrubs up to 17 m. tall; branches terete, smooth to striate, glabrous, black or reddish-brown; lenticels lacking or obscure; axillary buds conoid, about 2 mm. long. Leaves ovate to elliptic, the apex acute to acuminate, the base shortly cuneate, obtuse to rounded, the margins serrate to nearly entire, 5–16 cm. long, 2.5–7.5 cm. wide, firmly membranous, lucid and usually blackish-brown on both sides or yellowish-green below in dry condition, the primary lateral veins 4–7 pairs, curved toward the apex, conspicuous and elevated below, plane above, the veinlets distinct and slightly elevated below, immersed and obsolete above; stipules laciniate, about 1 mm. long; petioles 6–13 mm. long. Inflorescences axillary, soli-

[30] Woodson, R. E., Jr. Some dynamics of leaf variation in *Asclepias tuberosa*. Ann. Mo. Bot. Gard. 34:353–432. 1947.

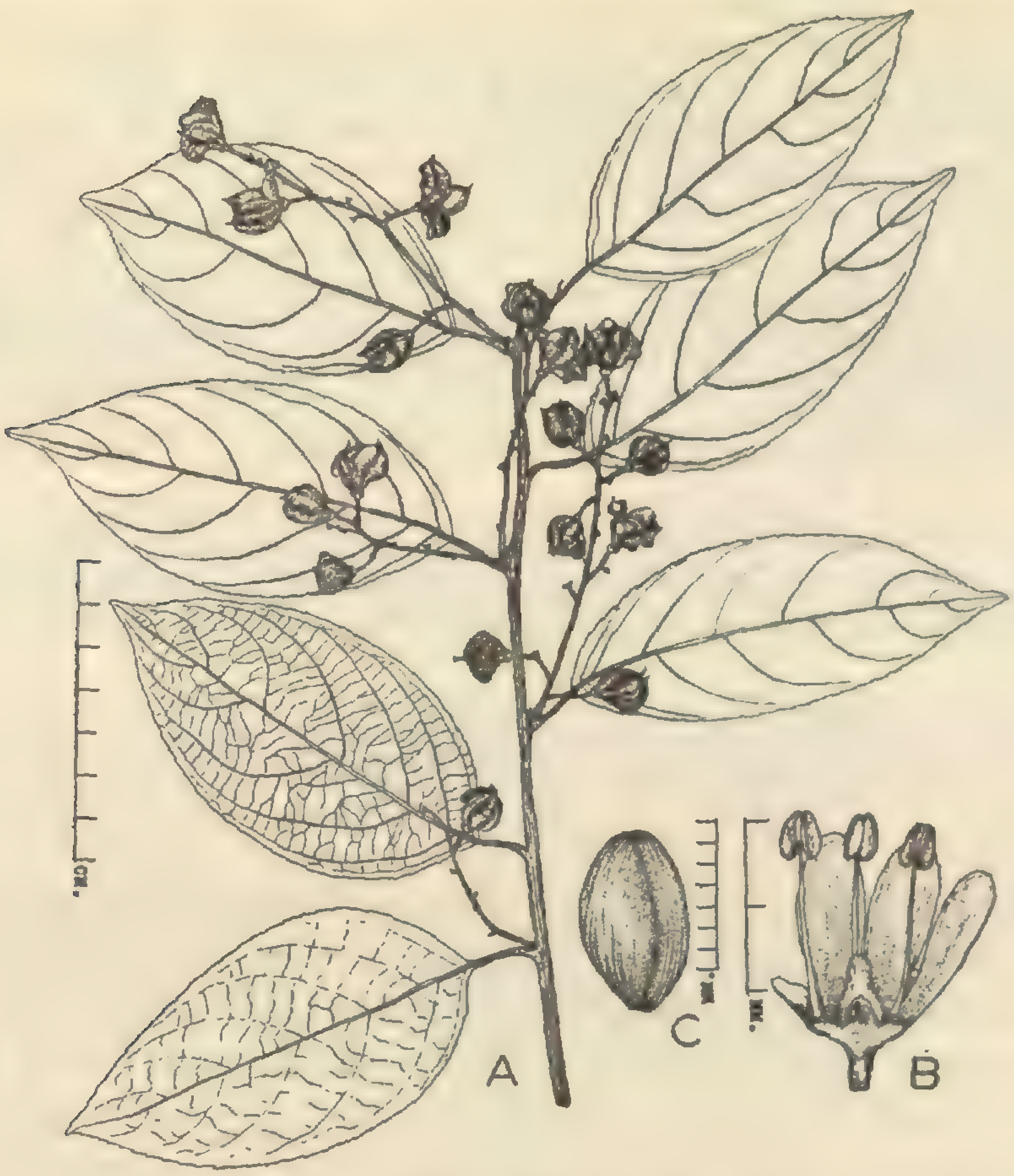


Fig. 6. *Celastrus monospermoides* Loes.

tary or in clusters of three, aggregate dichasia, frequently fasciculate-racemiform, once to thrice compound, up to 10 cm. long, the peduncles glabrous, the primary peduncles obscure to 16 mm. long; flowers dioecious, white, the pedicels about 4 mm. long, the articulation at the basal part of the stalk. Male flowers: calyx lobes imbricate, suborbicular, entire, about 0.7 mm. long; petals oblong, the apex rounded, about 2 mm. long and 1 mm. wide, entire, pink-punctate; disc fleshy, plane, the lobes obscure, truncate; stamens attached slightly under the margin of the disc, about 2.5 mm. long, the filaments filiform, glabrous, the anthers ovoid and obtuse; sterile pistil conoid, 2 mm. long. Female flowers: calyx lobes, petals, and disc as in the male, sterile stamens about 0.7 mm. long; pistil flask-shaped, 1.2 mm. long, the ovary globose, the style slender, distinct, the stigmata discoid. Fruits angular-ovoid, obovoid to subglobose, the valves ovate or obovate to broadly elliptic, about 12–17 mm. long and 7–11 mm. wide; seeds ovoid, about 7–12 mm. long and 5–10 mm. wide, blackish-brown, smooth.

In dense woods, at altitudes 100–3,300 m.; Borneo, Indonesia, Malaya, New Guinea, and Philippines; flowering from January to September.

BORNEO: western Koetai, *Endert 3846* (L). BRITISH NORTH BORNEO: Kini Taki River, *J. & M. S. Clemens 31827* (A, L), *32052* (L); Marai Parai, *J. & M. S. Clemens 32860* (L), *33182* (L, UC); Penibukan, *J. & M. S. Clemens 32120* (L), *50253* (L, UC); Upper Kinabalu, *J. & M. S. Clemens 27879, 29919* (L), *50641* (A), *51295* (A, L, UC).

SUMATRA: Gaju & Alas Land, *van Steenis 8717* (L), *9651* (A, L); old jungle near the Ack Kanopan, Loendoet concession, Koeale, *Bartlett 6864* (F, MICH, NY, US); Laboebom Batoe, Kota Pinang, *Toroes 4009* (A, NY, UC, US).

MALAYA: SELANGOR: *Ridley 8228* (SING). NEGRI SEMBILAN: Sutu, *Alims 1605*, *2103* (SING). PENANG: Government Hill, *Curtis 404* (SING), *Ridley 404* (SING, paratype of *Celastrus malayensis*); Telom, *Ridley 13538* (SING, paratype of *C. malayensis*); top of Penang Hill, *Ridley 7127* (SING). PERAK: Batu Petch, *Wray 1031* (SING, paratype of *C. malayensis*); Hijan, *Haneeff & Jan 2466* (SING); Larut, *Dr. King's collector 5690* (L, SING, UC, UPS), *6928* (L, US); Maxwell's Hill, *Curtis 2005* (SING), *Ridley s. n.*, 1890 (A); Tapa, *Wray 175* (L). SINGAPORE: Sungei Loyang, *Mat s. n.*, 1894 (SING).

NEW GUINEA: DUTCH NEW GUINEA: Bali, *Stresemann s. n.*, May–Aug. 1911 (L): s. w. of Bernhard Camp, Idenburg River, *Brass 12999* (A, L); Dalman, 45 km. inward of Nabire, *Kanehira & Hatusima 12102* (A); southern New Guinea, via Resi Mts. to Hellwig Mts., *Versteegh 1643* (L, type of *Celastrus monospermoides*). NORTHEAST NEW GUINEA: Ogeramnang, Morobe, *J. & M. S. Clemens 4581, 5084, 6253* (A). PAPUA: Boridi, *Carr 13036* (A).

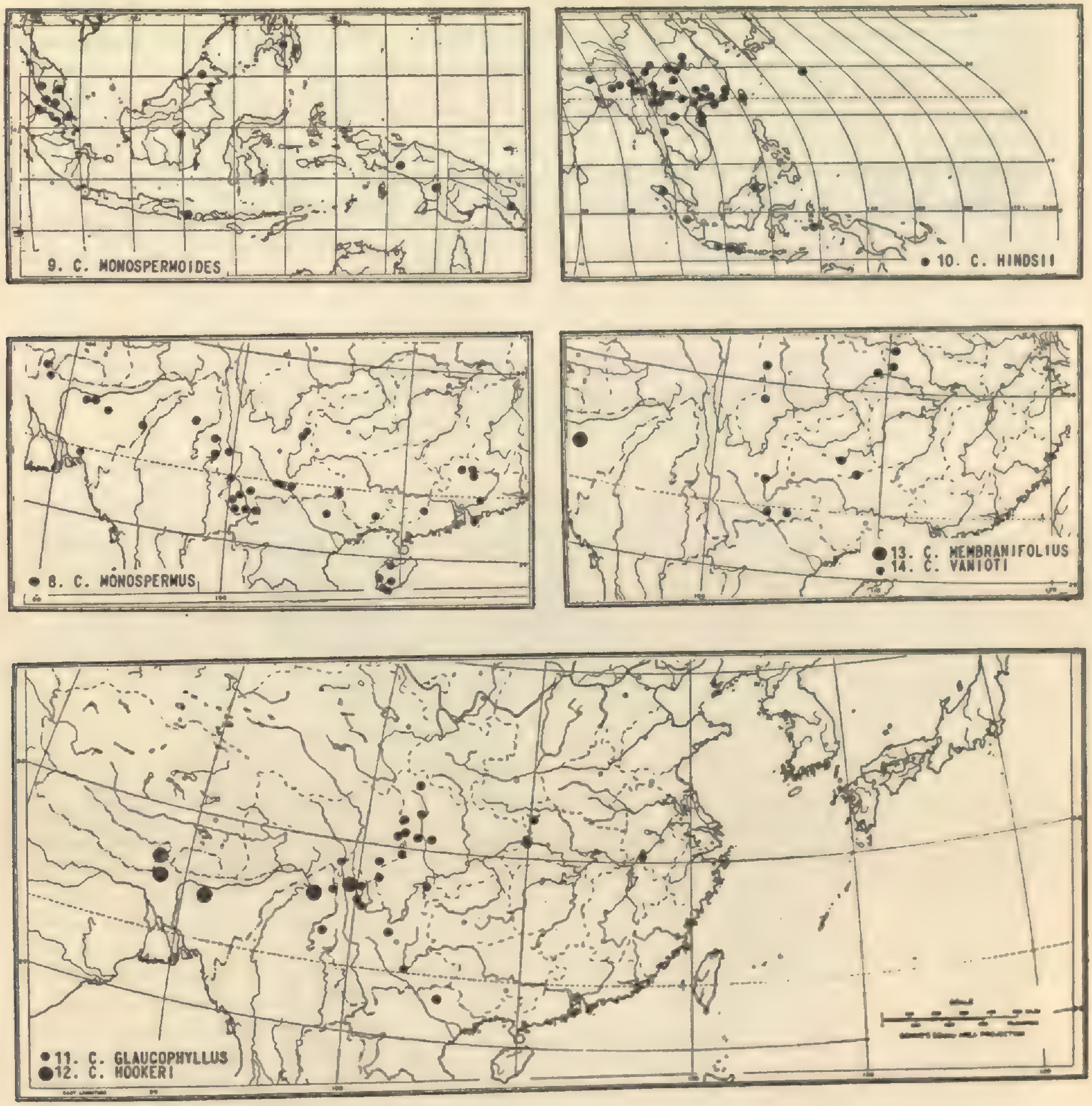
PHILIPPINES: MINDANAO: Davao, Mt. Apo, *Elmer 11411* (A, type of *Celastrus apoensis*, GH, L, MO, NY, US); Mt. McKinley, *Edaño 900* (A, L, SING, UC); Bukidnon, Mt. Dumalucpihan, *Ramos & Edaño 38961* (A, L, US); Mt. Katanglad, *Sulit 3188, 3421, 9917, 10086* (L).

The wide distribution, within geographically isolated areas, and the morphological variations of this species are the causes of several names. Specimens collected in the Malay Peninsula from lowlands up to 1,330 m. altitude have leaf forms varying from ovate to elliptic. They have thick and large leaves and long inflorescences. A specimen (*van Steenis 9651*, A, L) collected at altitude 3,000 m. from northern Sumatra has small and thin leaves and short inflorescences—about 1 cm. long.

The type specimen of *Celastrus apoensis* Elmer from Mt. Apo (alt. 2,000 m.), Mindanao, Philippines, has unusually small leaves. In addition, two other specimens (*Sulit 9917* and *10086*, L) collected at altitudes 1,700–1,800 m. from Mt. Katanglad, Mindanao, have larger leaves. The shapes and textures of leaves and inflorescences are similar to those from Malaya, Borneo, and New Guinea in similar environments.

There are several collections from Mt. Kinabalu, North Borneo, at altitude about 3,000 m. The leaf form is ovate with rounded base which is very distinctive and might be thought as a form of this species. In addition, there is a specimen (*Endert 3846*, L) collected at altitude 1,200 m. from east-central Borneo having elliptic leaves, acute at both ends. I think it may be possible, in addition to those mentioned above, to find more specimens with various leaf forms from different environments.

The leaves of the New Guinea specimens are usually elliptic, acute at both ends. They are quite similar to those from other localities in similar environments. I have made some studies and measurements of leaf characters. Except those from Mt. Kinabalu, Borneo, they can hardly be separated into groups. The shapes and sizes of fruits are variable also. As far as the shapes of fruits are concerned, those of the Malayan specimens seem to be broadly elliptic while those of the Philippine specimens are obovate. However, they display intermediate forms as well.



Map 2. Distribution of seven species of *Celastrus*, Subgenus CELASTRUS, Series II. AXILLARES.

10. CELASTRUS HINDSII Benth. in Hook. Jour. Bot. 3:334. 1851, ex char. (T.: *Hinds s. n.*).

Catha monosperma (Roxb.) Benth. in Hook. Lond. Jour. Bot. 1:483. 1842, quoad descr. & spec. cit., non sensu Roxb.
Celastrus venulosus Wall. Cat. no. 4321. 1831, nom. nud.
Celastrus racemulosus Hassk. Hort. Bogor. Descr. 1:1915. 1858, ex char.
Flueggea serrata Miq. Fl. Ind. Bat. 1:356. 1859. (T.: *Junghuhn s. n.*, L!).
Celastrus monosperma sensu Benth. Fl. Hongk. 63. 1861, non Roxb.
Celastrus cantonensis Hance, in Jour. Bot. 23:323. 1885. (T.: *Hance 22191*, A, a photo and a fragment of a leaf!).
Celastrus hindsii Benth. var. *henryi* Loes. in Engl. Bot. Jahrb. 29:444. 1901; 30:467. 1902. (T.: *Henry 3495*, A!).

Celastrus oblongifolia Hay. Icon. Pl. Formos. 3:58. 1913. (T.: *Hayata s. n.*, A!).
Celastrus marianensis Koidz. in Bot. Mag. Tokyo 30:400. 1915, ex char. (T.: Koidzumi *s. n.*).
Celastrus axillaris Ridley, in Jour. Roy. Asiat. Soc. Malay. Branch, 1:56. 1923, ex char.
Celastrus approximata Craib, in Kew Bull. Misc. Inf. 1926:349. 1926. (T.: *Kerr 9941*, SING!).
Celastrus merrillii Tardieu, in Bull. Soc. Bot. France 95:180. 1948; in Fl. Gén. l'Indo-Chine Suppl. 1:805. *fig. 98, t. 1, 2* & *3*. 1948. (T.: *Poilane 28714*, P!).

Fig. 7. *Celastrus hindsii* Benth.

Scandent shrubs up to 19 m. tall; branches terete, glabrous, brown, rarely lenticelled, the branchlets smooth and green, the lenticels usually lacking on the current season's growth; axillary buds deltoid, about 1 mm. long. Leaves elliptic-oblong, obovate-oblong, elliptic or rarely broadly elliptic, the apex abruptly acute to acute, the base cuneate to obtuse, the margins remotely and obscurely serrate to serrate, 4.0–14.5 cm. long, 1.5–6.0 cm. wide, coriaceous, shining, glabrous, the primary lateral veins 6–9 pairs, the veins and veinlets usually distinctly elevated and densely reticulated on both surfaces, rarely slightly elevated or obsolete above; stipules laciniate, about 1 mm. long; petioles about 0.5–1.0 cm. long. Inflorescences usually axillary as well as terminal, sometimes axillary only, solitary, usually 3- to 5-flowered, or sometimes racemiform and longer than the subtending leaf, the

peduncles glabrous, the primary peduncles almost obsolete to 5 mm. long, rarely up to 25 mm. long; flowers dioecious, white to pale yellow, the pedicels almost obsolete to 5 mm. long, the articulation on the upper half of the stalk. Male flowers: calyx lobes semi-orbiculate, imbricate, obtuse, ciliate, about 1.5 mm. long; petals oblong to obovate, obtuse, glandular-ciliate, 2–5 mm. long and 1.3–2.5 mm. wide; disc cup-shaped, the lobes usually deltoid, rarely slightly oblong, shortly acute, rounded, or slightly dentate; stamens arising from the margin of the disc proper, about 2.3 mm. long, the filaments subulate, glabrous, the anthers ovoid, obtuse, cordate; sterile pistil ovoid, about 1.5 mm. long. Female flowers: calyx lobes, petals, and disc as in the male, but the petals smaller; sterile stamens about 1.5 mm. long, the ovary subglobose, the style columnar, the stigmata 3-lobed. Fruits ovoid to subglobose, the valves broadly ovate to suborbicular, about 8–11 mm. long and 7–9 mm. wide, usually 1-seeded; seeds cylindric, 5–8 mm. long and 5 mm. wide, reddish-pink, smooth.

Chiefly in thickets, at altitudes from 232–1,800 m.; Bonin Islands, Burma, China, India, Indonesia, Indo-China, and Siam; flowering from January to October.

BRITISH NORTH BORNEO: Penibukan, *J. & M. S. Clemens 30493* (A, L, UC).

BURMA: Kachin Hills, *Shaik Mokim s. n.* (CAL); Kaitao, *Toppin 4292* (CAL); Kajen Lap., *Toppin 6154* (CAL).

CHINA: FUKIEN: Amoy, *Chung 335* (SING), *1771* (SING, UC), *4599, 4783, 4851, 5601* (A); Changchow, *Chung 1174, 1206* (A, UC); Chuanchow, *Chung 1084* (UC); Foochow and vicinity, *Sin Ging Tang 7039* (A), *7175* (MICH); Kuliang and vicinity, *Sin Ging Tang 6991* (MO, UC). HAINAN: Bak Sa, *Lau 26227* (A); Ching-mai Hsien, *Lei 129* (L, NY, SING, UC, US), *440* (NY, SING, UC, US); Hung-mo Shan and vicinity, Lai area, *Tsang & Fung 241* (A, US); Nodoa, *McClure s. n.* (A, MO); Yaichow, *How 70368* (A, F, NY); without precise locality, *Levine s. n.* (A, F, MO, US), *484* (A, F, GH, MO). HUPEI: Chang-lo Hsien, *Wilson 561*A (A); Enshih Hsien, *Ho-Ch'ang Chow 1944* (A, NY); Ichang, *Wilson 561* (A, F, GH, MO, US); Patung, *Ho-Ch'ang Chow 548* (A), *705* (A, NY), *Wilson 450* (A, NY); without precise locality, *Henry 3241* (NY, type of *Celastrus hindsii* var. *henryi*), *3495* (A, GH, US), *3856, 3495*A (GH), *v. Rosthorn 9* (A). KWANGTUNG: Au-tsai, *McClure 3544* (NY); Canton and vicinity, *Hance 22191* (A, photo of type of *Celastrus cantonensis*, with a piece of leaf), *Levine s. n.* (C.C.C. nos. *180*—A, UC; *441*—A, F, GH, MO, US; *1236*—A, GH, MO, US), *Merrill 10070* (UC), *Keng-ping To 1868* (UC); near Fung-wang, *Kang-ping To et al 889* (US); Kochow, *Tsiang 1002* (UC), *2300* (NY); Mei Hsien, *Tsang 21422* (A); Pok-Lor, *Hom Fung A-511* (NY); Sin-fung Hsien, *Taam 587, 759* (A); Sun-wui Hsien, *Tso & Tsiang 2024* (A, F); Tai-o, *Wang 3196* (NY); Tseng-shing, *Tsang 20209* (NY); Tsung-hwa Hsien, *Tsang 20604* (MO, NY), *25019* (A); Wung-yuen, *Lau 693* (A, NY, SING), *2672* (A); Ying-tak Hsien, *Tsui 391* (A, MO, NY, UC, US), *Tsiang 1919* (SING, UC), *Tsang & Kam-chow Wong 2661* (UC); Wung-yuen, *Lau 693* (A, SING). KWEICHOW: without precise locality, *Cavalerie 3976* (A). SZECHUAN: Kiating Fu, *Wilson 3324* (A); Omei Shan, *Chiao & Fan 458, 8639, 11712, 14981, 15221* (A); *Hu 7380* (A), *Lee 4551* (A), *Wilson 2307* (A, US), *Wang 8096* (A). TAIWAN: Aderu, Heito, *Suzuki 11162* (TAI); Arisan, *Faurie 1376* (A, TAI), *Hayata s. n.* (A, photo of type of *Celastrus oblongifolius*). YUNNAN: Che-li Hsien, *Wang 75846, 79467, 79470* (A); Chen-pien Hsien, *Ko 56089* (A); Jenn-yeh Hsien, *Wang 80136, 80181, 80232* (A); Lu-se, *Tsai 56342* (A); Luh-shuen Hsien, *Wang 81177* (A); Mar-li-po, Tung-ting, *Feng 13068, 13210, 13387, 13454, 13464, 13847* (A); Mengtze, *Henry 10559* (A, MO, NY, US), *Tsai 52375* (A); Si-chour Hsien, *Feng 11685, 11862* (A); Szemao, *Henry 11972*C (US); Tsing-pien, *Tsai 52545* (A). HONGKONG: *Chun 4840* (A, UC); *Hance 370* (GH); *Taam 1477, 2147* (US), *1798, 1951* (A, US); *Tsang 77* (UC); *Wight 91* (GH), *611* (GH, NY).

India: assam: Darrang, *Upendranath Kanjilal 4976* (CAL); Kegwima, Naga Hills, *Clarke 41911*[C] (CAL); Khasia, Tserra, *Clarke 5615* (CAL). sikkim: Duphla Hills, *Lister 68* (CAL).

Indo-China: Cho Gank, *Pételot 863* (A, UC), *991* (UC); Tonkin, *Pételot 340* (NY, US).

Indonesia: java: Thibeureum, *Arsin 19568* (L); Tjibodas, *Hallier 462* (A), *Valeton 102* (A), *Koorders 42439β* (L), *Valeton s. n.* (L, UC); Tjidadap, Tjibeber, *Winckel 92β, 98β* (L), *1633β* (L, UC), *1682β* (L, SING); Mt. Waripin, Premyer, *Forbes 961* (CAL), GH, L); without precise locality, *Forbes 921* (CAL, GH, L), *980* (GH), *980*[a] (CAL), *Junghuhn 27, 105* (L), *s. n.* (type of *Flueggea serrata* Miq., L), *Korthals 747* (A). moluccas: Amboina, *de Vrise & Teijsmann s. n.* (L). sumatra: Kabajakan to Tretel, *Walter & Bangham 870* (A, NY); Waldregion, *Junghuhn s. n.* (L).

Japan: bonin islands: Hah-jima, *Wilson 8300* (A).

Siam: Kao Lem, *Kerr 9941* (SING, type of *Celastrus approximata*); Mt. Doi Chang, Chiengma, *Rock 1744* (A, UC, US).

Bentham in 1842 determined a Hongkong plant, collected by Hinds, as *Catha monosperma* (Roxb.) Benth., based on *Celastrus monosperma* Roxb. Subsequently in 1851, he described the same specimen as representing a distinct species, *Celastrus hindsii* Benth. He commented in the discussion: "The form, size, and structure of the capsule are like those of *C.* [*Celastrus*] *paniculata,* without any narrowing of the base, as in *C. monosperma* and *C. Championi,* although it is always monospermous (by abortion) as in the two latter, not three-seeded as it usually is in *C. paniculata.* All these species belong to the true *Celastri,* not to *Catha,* to which I had erroneously referred them in my former paper". So he reduced *Catha monosperma* (Roxb.) Benth. (excl. syn. Roxb.) into synonymy under *Celastrus hindsii* Benth.; but in 1861 he again adopted *Celastrus monospermus* Roxb. for the Hongkong plant and reduced his own *Celastrus hindsii* to synonymy. Actually, *Celastrus hindsii* Benth. is readily distinguished from *Celastrus monospermus* Roxb. in both vegetative and reproductive structures, as Bentham has pointed out in the discussion under *Celastrus hindsii,* and the two species should be maintained as distinct.

The firmly membranous leaves usually are elliptic-oblong, shining, and densely reticulate; and the capsules usually one-seeded, which make this species very easily distinguished from the others.

I have seen a photograph of the type specimen and fragment of a leaf from the type of *Celastrus cantonensis* Hance. This plant has leaves, venation, and inflorescences which match the description of *Celastrus hindsii.*

The original description indicates that *Celastrus hindsii* var. *henryi* Loes. differs only from the typical variety by the larger and thicker leaves, and also the nearly immersed obsolete veins. Later (1916) Rehder and Wilson stated: "in addition to the characters given by Loesener the variety differs from the type species in having subsessile and very shortly peduncled cymes". In all the specimens seen, I have not been able to distinguish with certainty var. *henryi* from the typical variety. Also, this variety does not differ at all from the typical form of the species in geographical range. Thus, this variety is reduced to synonymy here.

A specimen collected from Yunnan by Wang (no. *76880*) has leaves like *Celastrus hindsii* whereas the fruits are similar to *C. monospermus.* This may be a hybrid between the two, if indeed they are distinct.

Fig. 8. *Celastrus glaucophyllus* Rehd. & Wils.

11. Celastrus glaucophyllus Rehd. & Wils. in Sarg. Pl. Wils. 2:347. 1915. (T.: *Wilson 952*, A!).

Celastrus rugosus Rehd. & Wils. loc. cit. 2:349. 1915. (T.: *Wilson 1106*, A!).
Celastrus orbiculatus sensu Tardieu, in Fl. Gén. l'Indo-Chine, Suppl. 1:806. 1948, non Thunb., as to spec. cited.

Scandent shrubs up to 2–5 m. tall; branches terete, glabrous, castaneous, the lenticels scattered, elliptic; branchlets glabrous, yellowish-brown, the lenticels lacking or obscure, rarely distinct; axillary buds ovoid, obtuse, about 3 mm. long. Leaves elliptic, obovate or ovate, the apex acute to shortly acuminate, the base rotund to broadly cuneate, the margins crenate-serrate, 4–13 cm. long, 2.5–8.0 cm. wide, firmly membranous, glabrous, or pubescent on the veins below, rarely bullate, usually glaucous or pale beneath, the primary lateral veins 5–7 pairs, elevated below, immersed to slightly elevated above, the veinlets distinct, slightly elevated below, immersed and obscure above; stipules laciniate, filiform, about 1.5 mm. long; petioles 5–15 mm. long. Inflorescences axillary as well as terminal, the axillary inflorescences 3- to 7-flowered, the terminal ones racemiform, usually 2–6

cm. long, the peduncles suppressed or up to 2 mm. long, glabrous, each associated with an axillary bud except the uppermost one of the terminal inflorescences; flowers dioecious, green, the pedicels about 2 mm. long, the articulation at the middle or upper half of the stalk. Male flowers: calyx lobes valvate, ovate, rotund, glandular-ciliate, about 1.5 mm. long; petals oblong, rotund, slightly erose, 3–4 mm. long and 1.0–1.5 mm. wide; disc membranous, the lobes ovate, obtuse; stamens 2.5–4.5 mm. long, the filaments filiform, the anthers ellipsoid; sterile pistil 1 mm. long. Female flowers: calyx lobes, petals, and disc as in the male; pistil flask-shaped, 5 mm. long, the ovary globose, the style distinct, slender, the stigmata 3-lobed, the lobes patent. Fruits subglobose, the pedicels accrescent, about 3–5 mm. long, the valves suborbicular, 7–10 mm. long and 8–9 mm. wide, 3- to 6-seeded. Seeds ellipsoid to slightly plano-convex, about 3–4 mm. long and 2 mm. wide, black, the areolae distinct.

Chiefly in mixed thickets, at altitudes from 700 to 3,300 m.; China and Indo-China; flowering from March to June.

CHINA: ANHWEI: Chu-hwa Shan, *Ching 2700* (UC), *Sun 1189* (NY). HUPEI: Chienshih Hsien, *Chow 1436* (A); Fang Hsien, *Wilson 357* (A, MO, US), *972* (A). SIKANG: Kangting (Tachien-lu), *Smith 13326* (UPS), *Wilson 4117, 4122* (A); I-tung, *Chiao 1721* (A); Tien-chuan Hsien, *Tai et al 5142* (A). SZECHUAN: Han-yuan Hsien, *Fang 3737* (A); inter Hohsi et Telipu, *Schneider 1131* (A); Juei-she Hsien, *Yu 941, 951* (A); west of Kuan Hsien, *Wilson 4317* (A); Mo-tien-ling, *Wang 22462* (A); Mupin, *Wilson 952* (A, holotype of *C. glaucophyllus;* GH, MO, US), *1148, 2310* (A, US), *3325* (A); Ning-yuan-fu, *Schneider 1027* (GH); Omei Shan, *Chiao & Fan 767* (A), *Chow 6448, 6468, 7597, 8028* (A), *Fang 3089* (A, NY), *12883, 13051* (A, US), *16624, 17317* (A), *Hu 7380* (A), *Lee 3561* (A), *Tai 204, 1071* (A), *Wilson 4782* (A); O-pien Hsien, *Yu-shih Liu 2231* (A), *Yu 750* (A); Ping-shan Hsien, *Wang 22643* (A); Sungpan Hsien, *Wilson 4157* (A), *Fang 4176* (A); Tu-yung-pu, *Schneider 4130* (A); Wa-shan, *Wilson 952*[A] (A), *1106* (A, type of *Celastrus rugosus;* MO); west of Wen-chuan, *Wang 21124* (A); Yen-yuan Hsien, *Schneider 4112* (A); Wa-shan, *Wilson 952*[A] (A); without precise locality, *Fang 1202* (A, NY), *Schneider 646, 647* (A). YUNNAN: Che-tse-lo, *Tsai 58555* (A); Chien-chuan-Mekong Divide, *Forrest 22235, 22475, 23230* (A, US); Chung-tien, *Feng 3299* (A); western flank of Haba Snow Range, *Feng 1226* (A); Hokin, *Feng 787* (A); Kumming, *Wang 62839* (A); Lan-ping Hsien, *Tsai 54026* (A); Mengtze, *Henry 9679* (NY, US); Pe-yen-tsin, *Ten 40* (A), *550* (A, US); Ping-pien Hsien, *Tsai 61004* (A); south of Red River, Manmei, *Henry 9679*[A] (A, MO, NY); Ta-pin-tze, *Ten 358* (A, US); Tengchuan, *Schneider 2874* (A, GH, US); Likiang, *Ching 20489, 20638, 21618* (A), *Feng 3047* (A), *Rock 3556* (A, UC, US), *3931* (A, US), *4032* (A, UC, US), *8312* (A), *8540* (A, NY, UC, US), *Schneider 1984, 2839* (A, GH); Wei-se Hsien, *Tsai 57899, 59824* (A).

INDO-CHINA: Chapa, Tonkin, *Pételot 5941* (A, NY).

12. CELASTRUS HOOKERI Prain, in Jour. Asiat. Soc. Bengal 73:179. 1904; Novic. Ind. 418. 1905. (T.: *Hooker s. n.,* CAL!).

Celastrus stylosa sensu Lawson, in Hook. Pl. Brit. Ind. 1:618. 1875 (pro parte, non Wall.).
Celastrus stylosa Wall. var. *Loeseneri* (Rehd. & Wils.) Tardieu, in Fl. Gén. l'Indo-Chine, Suppl. 1:806. 1948, sensu Tardieu, non Rehd. & Wils.

Scandent shrubs up to 10 m. tall; branches terete to slightly striate, glabrous, brown to reddish-brown, the lenticels sparse or lacking on the current year's growth, suborbiculate to elliptic; axillary buds conoid, 2–4 mm. long, the bud

scales accrescent, persistent. Leaves broadly elliptic to ovate, the apex acute, the base obtuse, the margins serrate, 6–12 cm. long, 4–7 cm. wide, thin-membranous on flowering branches, glabrous, the primary lateral veins 5–6 pairs, slightly elevated below, immersed and distinct above, the veinlets visible below, obscure above, relatively thick-membranous on fruiting branches; stipules laciniate, about 1.5 mm. long; petioles 8–15 mm. long. Inflorescences axillary as well as terminal, the axillary ones 3- to 5-flowered, the primary peduncles glabrous, about 1.5–3.5 mm. long, the terminal inflorescences very short-pedunculate dichasia, fasciculate or solitary, about 4 cm. long, the axils of the peduncles associated with vegetative buds (except the uppermost); flowers dioecious, green, the pedicels 1.5–2.4 mm. long, the articulation on the upper half of the stalk. Male flowers: calyx lobes deltoid, imbricate, ciliate, about 1.5 mm. long; petals oblong to obovate, slightly glandular on the margins, about 3.5 mm. long and 1.5 mm. wide; disc cup-shaped, the lobes subreniform; stamens arising from the margin of the disc proper, about 2 mm. long, the filaments linear, glabrous, the anthers apiculate; sterile pistil 1.5 mm. long. Female flowers: calyx lobes, petals, and disc as in the male, the sterile stamens 1.5 mm. long, the pistil 4 mm. long, the ovary globose, narrowed into a distinct style, the stigmata 3-lobed, each lobe bifid, linear. Fruits subglobose, the valves broadly elliptic, about 10 mm. long and 7 mm. wide, 3- to 6-seeded; seeds ellipsoid or ovoid, about 4 mm. long and 2 mm. wide, black, the areolae distinct.

Chiefly in thickets, at altitudes from 1,525 to 3,050 m.; Burma, India, China, and Pakistan; flowering from March to May.

BURMA: Adung Valley, *Kingdon Ward 9455* (A); Bhamo, Lapyeka to Sinlum Kaba, *Lace 5775* (CAL); without precise locality, *Prazer s. n.*, 1890 (CAL), *Lace 5753* (CAL).

CHINA: YUNNAN: between Chienchuan Plain and the Mekong drainage basin to Lachining, *Rock 8615* (A, UC, US); Wei-se Hsien, *Tsai 59901* (A); without precise locality, *Yu 8491* (A).

INDIA: ASSAM: Khasia, *Griffith 605* (CAL). BENGAL: Darjeeling, *Clarke 682*[C], *27040*[D], *35758*[E] (CAL), *Gamble 1926*[A] (CAL); Jalubaham, *King s. n.*, May 9, 1876 (CAL). SIKKIM: Lachung, *Gammie 1179* (CAL); Lachen, *Dr. King's collector s. n.*, May 1885 (CAL); Lebong, *Kurz s. n.* (CAL); Pauree, *Dr. Prain's collector 289* (CAL); Lachen, *Clarke 46569* (CAL). WITHOUT PRECISE LOCALITY: temp. region, 8,000–10,000 ft., *Hooker s. n.* (type of *Celastrus hookeri*, CAL), *Kurz s. n.* (CAL).

PAKISTAN: *Griffith 1993* (CAL, GH).

Rehder and Wilson [31] have cited two Indian specimens, *Hooker & Thomson*, "Khasia, alt. 4–5,000 ped." and *C. G. Rogers*, "Sikkim, January 1900", as *Celastrus hookeri* Prain. Actually, they are *Celastrus stylosus* Wall. As it was stated by Prain, "The two can be at once distinguished by the stamens which have hirsute filaments in *Celastrus stylosus*, but glabrous ones in Hooker's species". In addition, the intercalary inflorescences and slightly lunate seeds of *Celastrus stylosus* are easily distinguished from terminal inflorescences and ovoid seeds of *C. hookeri*.

13. CELASTRUS MEMBRANIFOLIUS Prain, in Jour. Asiat. Soc. Bengal 73:197. 1904; Novic. Ind. 418. 1905. (T.: *Mann s. n.*, CAL!).

Branches terete, the branchlets slightly angular on the dry specimens, glabrous,

[31] Rehder, A., and Wilson, E. H., in Sarg. Pl. Wils. 2:352. 1915.

the lenticels scattered, ovate or orbiculate; axillary buds conoid, acute, about 1.5 mm. long. Leaves ovate-lanceolate to elliptic, the apex acuminate, the base cuneate, the margins serrate, 7.5–14.0 cm. long, 3.5–5.5 cm. wide, membranous, pale green in dry condition, glabrous, the primary veins 4–5 pairs, elevated below, immersed or slightly elevated above, the veinlets prominent on both surfaces; petioles 1.0–1.5 cm. long. Flowers unseen. Fruiting inflorescences axillary as well as terminal, short-pedunculate or fasciculate, associated with axillary buds, the stalks 7–15 mm. long, the articulation on the upper half of the stalk. Fruits subglobose, the valves broadly elliptic, about 7 mm. long and 5 mm. wide, 3- to 6-seeded; seeds elliptic, rotund at both ends, wrinkled (immature?), black, about 2–3 mm. long and 1–2 mm. wide.

INDIA: ASSAM: Khasia and Junteah Hills, *Mann s. n.*, 1877 (CAL, type; MO); Khasia Hills and Brahmaputra plains, *Kurz s. n.* (CAL).

The few specimens available are fruiting specimens in which the seeds are highly wrinkled, indicating that they might be immature. However, I have seen no immature seeds with such wrinkling in any other species of *Celastrus*.

14. CELASTRUS VANIOTI (Lévl.) Rehd. in Jour. Arn. Arb. 14:249. 1933.

Saurauja vaniota Lévl. Fl. Kouy-Tchéou, 415. 1915. (T.: *Bodinier s. n.*, A!).
Celastrus spiciformis Rehd. & Wils. in Sarg. Pl. Wils. 2:348. 1915. (T.: *Wilson 2312*, A!).
Celastrus spiciformis var. *laevis* loc. cit. 2:349. 1915. (T.: *Wilson 1176*, A!).

Scandent shrubs up to 10 m. tall; branches terete or slightly striate, glabrous, light brown to reddish or fuscous, the lenticels scattered, orbicular or elliptic, sometimes lacking on the current year's growth, slightly elevated on the older branches; axillary buds globose, about 2 mm. long. Leaves ovate or elliptic, the apex acute to shortly acuminate, the base rotund to shortly cuneate, the margins crenate-serrate, the teeth incurved, glandular-mucronate, 5–13 cm. long, 3.5–7.5 cm. wide, membranous, glabrous or slightly puberulous on the veins below, the primary lateral veins 6–7 pairs, slightly elevated on both surfaces, the secondary lateral veins parallel; stipules laciniate, filiform, about 1.5 mm. long; petioles 1–2 cm. long. Inflorescences axillary as well as terminal, shortly pedunculate or fasciculate, the peduncles almost obsolete to 5 mm. long, the axillary inflorescences dichasia or very short-racemiform, sometimes lacking in the axils on the current season's growth, the terminal inflorescences fasciculate-racemiform, 6–18 cm. long, associated with axillary buds; flowers dioecious, greenish-white, the pedicels about 2 mm. long, the articulation at the middle or on the lower half of the stalk. Male flowers: calyx lobes deltoid, imbricate, obtuse, glandular-ciliate, about 1 mm. long; petals oblong, rotund, slightly erose, about 3 mm. long and 1.5 mm. wide; disc cup-shaped, membranous, the lobes acute; stamens arising from the margin of the disc proper, about 2.5 mm. long, the filaments linear, glabrous, the anthers ovoid, obtuse, slightly apiculate; sterile pistil conic, about 1 mm. long. Female flowers: calyx

lobes, petals, and disc as in the male; sterile stamens 1 mm. long; pistil 3 mm. long, the ovary ellipsoid, gradually attenuate into the style, the stigmata 3-lobed and spreading. Fruits subglobose, the valves broadly ovate, about 9 mm. long and 8 mm. wide, 3- to 6-seeded; seeds ellipsoid, obtuse at both ends, areolae distinct, about 4 mm. long and 2 mm. wide, black.

In mixed woods, at altitudes from 500 to 2,000 m.; China; flowering from May to July.

CHINA: HUNAN: Wukang, *Te-hui Wang 113* (A). HUPEI: Fang Hsien, *Wilson 2215* (A, NY); Heing-shan Hsien, *Wilson 2312* (A, type of *Celastrus spiciformis;* GH, MO); without precise locality, *Henry 5935* (A, GH, US), *Wilson 2215*[a] (NY). KWEICHOW: Bin Long, Miu Shan, Luchen, *Ching 6057* (NY); Tuhshan, *Tsiang 6655, 6993* (NY); without precise locality, *Bodinier 2287* (A, type of *Saurauja vanioti*). SZECHUAN: Loo-shan Hsien, *Wang 23582* (A); Ma-pien Hsien, *Wang 23101* (A); Omei Shan, *Chow 7094* (A), *Fang 18958* (A), *Sun & Chang 149, 286* (A), *Wang 8035* (A, US); Wa-shan, *Wilson 1176* (A, holotype of *Celastrus spiciformis* var. *laevis*), *1383* (A, NY). YUNNAN: Mengtze, *Henry 11006* (A, MO, NY); Tong Tch'ouan, *Maire 6227* (UC); Wen-shan Hsien, *Feng 11165* (A); Yi-liang Hsien, *Tsai 52090* (A).

Celastrus vanioti, as pointed out by Rehder and Wilson, "is a puzzling plant somewhat intermediate in character between *C. angulata* Maximowicz and *C. hypoleuca* Warburg". It appears to be a hybrid between those two species. Superficially, the type of *C. spiciformis* is similar to *C. angulatus,* except for the inflorescences which are both terminal and axillary. On examination, the floral structures were found to be similar to those of *Celastrus hypoleucus.*

15. CELASTRUS HYPOLEUCUS (Oliv.) Warb. apud Loes. in Engl. Bot. Jahrb. 29:445. 1900 (as *hypoleuca*).

Erythrospermum hypoleucum Oliv. in Hook. Icon. III, 9:*t. 1899.* 1889, ex char. & ill. (T.: *Henry 5877*).
Celastrus hypoglaucus Hemsl. in Ann. Bot. 9:150. 1895. (T.: *Henry 2837,* GH!).
Celastrus hypoleucus forma *α genuina* Loes. in Diels, in Engl. Bot. Jahrb. 29:445. 1900 (based on *Erythrospermum hypoleucum* Oliv.).
Celastrus hypoleucus forma *β argutior* Loes. loc. cit. 1900. (T.: *Henry 6771,* A!).

Scandent shrubs 3–5 m. tall; branches slightly striate, glabrous, darkish brown, the lenticels sparse to dense, rarely lacking on the current year's growth; axillary buds orbicular, about 2 mm. in diameter. Leaves elliptic to elliptic-oblong, the apex acute, the base obtuse, the margins remotely serrate to serrulate, 3.0–9.5 cm. long, 2.0–5.5 cm. wide, usually delicately membranaceous, glabrous, sometimes puberulous on the veins below, glaucous below, pallid above, the primary lateral veins 5–6 pairs, slightly elevated below, immersed above, the veinlets prominent below, obscure above; stipules filiform, about 2 mm. long; petioles 1–2 cm. long. Inflorescences axillary as well as terminal, the terminal portion usually up to 10 cm. long, usually short-pedunculate, the peduncles glabrous, accrescent, the primary peduncles usually 2–8 mm. long; flowers dioecious, light green or yellow, the pedicels accrescent, about 2–8 mm. long, the articulation at the upper half of the stalk, after anthesis usually only the flowers of the terminal inflorescences maturing into fruits, and the stalk accrescent up to 4 cm. long, spreading and

pendulous. Male flowers: calyx lobes valvate, deltoid to oblong, subentire to slightly erose, about 1.5 mm. long; petals oblong or rarely elliptic, usually entire, rarely obscurely erose, about 4.3 mm. long and 2 mm. wide; disc cup-shaped, the lobes obscure, truncate to mucronate; stamens arising from the margin of the disc proper, about 4 mm. long, the filaments filiform, glabrous, about 3 mm. long, the anthers ovoid, slightly apiculate, about 1.5 mm. long; sterile pistil about 2 mm. long. Female flowers: calyx lobes, petals, and disc as in the male; sterile stamens about 1.5 mm. long; pistil flask-shaped, about 3 mm. long, the ovary ellipsoid, the style cylindric, distinct, the stigmata 3-lobed, flat, spreading. Fruits subglobose, the valves broadly elliptic or suborbicular, about 8–12 mm. long and 8–10 mm. wide, irregularly pink-punctate within, 3- to 6-seeded; seeds more or less plano-convex to slightly lunate, attenuate at both ends, about 6 mm. long and 2 mm. wide, black-brown, the areolae distinct.

Chiefly in thickets, at altitudes from 1,700 to 2,745 m.; China; flowering from June to July.

China: anhwei: Wang Shan, *Ching 3065* (UC). hupei: Fang Hsien, *Wilson 362* (A, F, GH, MO, US); Hsun-tien-tsze, *Chun 4427* (A); Ichang, *Wilson 1063* (A, NY); without precise locality, *Henry 2837* (GH, paratype of *Celastrus hypoglaucus*), *5887* (GH, NY, US), *6811* (GH), *6771* (A, type of *Celastrus hypoleucus* forma β *argutior;* US). shensi: Kin-qua Shan, *Giraldi s. n.*, July 10, 1897 (A); Qua-in Shan, *Giraldi s. n.*, July 16, 1897 (A); Tai-pei Shan, *Giraldi s. n.*, July 15–20, 1897 (A); Tsinling, *Fenzel 927* (A). szechuan: Kuan Hsien, *Wilson 2306* (A, US).

This species is easily recognized by its long terminal pendulous racemiform dichasia of long accrescent stalked fruits and by the slightly lunate seeds. The leaves are usually glaucous below, but this character is extremely variable.

16. Celastrus gemmatus Loes. in Engl. Bot. Jahrb. 30:468. 1901 (as *gemmata*). (T.: *Henry 9872*A, MO!).

Embelia esquirolii Lévl. in Fedde, Rep. Sp. Nov. 10:374. 1912. (T.: *Esquirol 4*, A!).
Celastrus lokchongensis Masamune, in Trans. Nat. Hist. Soc. Formosa 25:15. 1935. (T.: *Tsiang 1346*, A!).

Scandent shrubs, 3–7 m. tall; branches terete or slightly striate, light to darkish brown, the lenticels scattered, suborbicular or oval, usually elevated, white; axillary buds conoid, acuminate, about 4–11 mm. long. Leaves usually broadly elliptic to elliptic-ovate, the apex gradually acuminate to acute, the base obtuse, rotund or truncate, the margins serrate, 5–15 cm. long, 2–8 cm. wide, firmly membranous, usually glabrous, rarely yellowish-puberulous on the veins below, the primary lateral veins 5–7 pairs, curved toward the apex, the veinlets densely reticulate, the veins and veinlets elevated on both surfaces; stipules filiform, tufted, about 1.5 mm. long; petioles 1.0–2.5 cm. long. Inflorescences axillary, usually 3- to 7-flowered, the peduncles glabrous, the primary peduncles 4–7 mm. long; flowers dioecious, white or yellowish-green, the pedicels 3–8 mm. long, the articulation at the lower half of the stalk. Male flowers: calyx lobes valvate, ovate-deltoid, obtuse, glandular-ciliate, about 1 mm. long; petals subequal, obtuse,

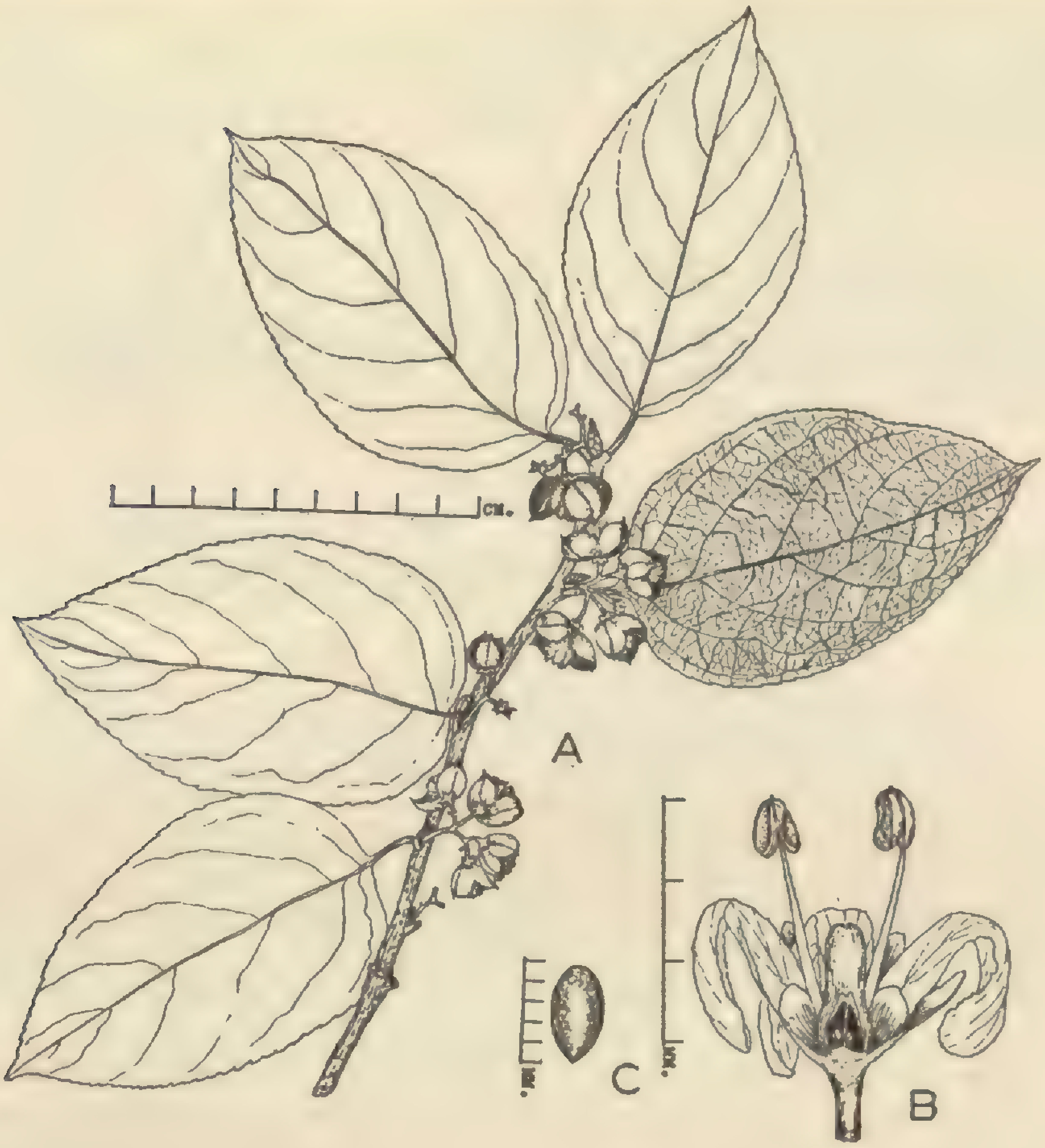


Fig. 9. *Celastrus gemmatus* Loes.

slightly erose, about 3.5–4.5 mm. long and 1.5–2.0 mm. wide; stamens inserted between the disc lobes, about 3 mm. long, the filaments more or less complanate, glabrous, gradually tapered toward the apex, the anthers oblong-ellipsoid, obtuse, usually apiculate, pink-punctate; disc thin, cup-shaped, the lobes acute; sterile pistil columnar, 1.5–2.5 mm. long. Female flowers: calyx lobes and petals as in the male; sterile stamens about 1 mm. long; disc thin, cup-shaped, the lobes inconspicuous; pistil flask-shaped, about 4 mm. long, the ovary ovoid, the style columnar, the stigmata 3-lobed, each bifid, reflexed. Fruits usually 1–3 on each dichasium, the pedicels green, the fruits subglobose, the valves broadly oval or suborbicular, 7–15 mm. long and 7–15 mm. wide, 3- to 6-seeded; seeds ellipsoid or ovoid, about 4.5 mm. long and 2.5 mm. wide, reddish-brown, smooth.

Common in thickets, valleys or open slopes, at altitudes from 400 to 3,000 m.; widely distributed in China: south of the Yangtze River; flowering from April to October.

CHINA: ANHWEI: Chu-hwa Shan, *Ching 2638* (A, UC), *7566* (UC); Wang Shan, *Ling 1159, 1246* (UC); Wu-yuen, *Ling 1349* (UC). CHEKIANG: east Tien-mu, *Hu 1585* (A, UC). FUKIEN: Dingschou, Tienhwa-schan, *Wang 399* (A). HUPEI: Fang Hsien, *Wilson 919* (A, NY), *2215*[a] (A); Sin-shan Hsien, *Wilson 363* (A, MO, US), *502* (A, F,

GH, MO, US); Patung Hsien, *Ho-Ch'ang Chow 901* (A, NY); Wan-tsao Shan, *Chun 3884* (A), *4229* (US); without precise locality, *Henry 7614* (GH). KIANGSI: Hsin-feng Hsien, *Hu 1119* (A); Lu-shan, *Chung & Sun 592* (A, NY), *Steward 1234* (A), *5470* (A, UC, US), *Wilson 1519* (A, MO, US). KIANGSI ET FUKIEN: in monte Dunghwa-schan inter Schitscheng et Ninghwa, *Wang 299* (A). KWANGSI: Tunghua Shan, Thwang, *Tsiang 10047* (NY); Tzu-yuen Hsien, *Chung 83605* (A); Huangtung, Yao-shan, *Sin 11835* (NY). KWANGTUNG: Jen-hwa Hsien, *Tsang 26404* (A); Lokchong, *Chun 42959* (A), *Tsang 20855* (A, L, MO, NY, SING, UC, US), *Tsiang 1346* (A, isotype of *C. lokchongensis*, UC), *1419* (A, UC); Tsungfa, *Tsang 25189* (A); Yang-shan Hsien, *Tsui 763* (MO, NY). KWEICHOW: Nan-kan, Cheng-feng, *Tsiang 4661* (A, NY); Pinfa, Kweiting, *Tsiang 5360* (A, NY); Tsingchen, *Teng 90254* (A); Tungtze, *Chun 5013* (A, S, UC), *Tsiang 5013* (NY); Yao-ren Shan, Sanhoa, *Tsiang 6450* (A, NY); without precise locality, *Esquirol 4* (A, type of *Embelia Esquirolii*). SIKANG: Kangting (Tachien-lu), *Smith 12898* (S), *Wilson 1302* (A, MO, US). SZECHUAN: Kuan Hsien, *Fang 2124* (A, NY); Mo-tien-ling, *Wang 22451* (A); Monkong-ting, *Wilson 2305*ᴬ (A); Mow Hsien, *Fang 5529* (A); Nan-chuan Hsien, *Fang 593* (A); Omei Shan, *Chow 9906* (A), *Fang & Lee 3575* (A, US), *Yu-shih Liu 1147, 1423* (A), *Tai 1113, 1120* (A); O-pien Hsien, *Sun 781* (A); Pao-Hsing Hsien, *Chu 3761* (A); Wen-chuan Hsien, *Wilson 2305* (A, MO, US); Yun-ching Hsien, *Sun 1247* (A). YUNNAN: Chien-chuan-Mekong Divide, *Forrest 21464, 22311* (A, US); Chungtien, *Feng 2868* (A), *Rock 24679* (A, MO, NY, UC, US); in the mountain above Dashao, *Handel-Mazzetti 13074* (A); between Kambaiti and Tengyueh, via Kuyung, *Rock 7568* (A, UC, US); Kunming, *Wang 62990* (A); Likiang *Ching 20682* (A), *Rock 3799* (A, UC, US), *4195* (A, US); Mengtze, *Henry 9782* (A, NY), *9782*ᴬ (A, type of *C. gemmatus;* MO), *10531* (A, paratype of *C. gemmatus;* MO, NY, US), *11471* (A, paratype of *C. gemmatus;* MO, NY); Muli Wachin, *Yu 14375* (A); Ping-pien Hsien, *Tsai 61004* (A); south of Red River from Manmei, *Henry 9679*ᴬ (A); between Shweli and Yengyueh valleys, *Forrest 8704* (A, S), *11173, 12050* (A); Suen-oui, *Maire 14* (A); Tali, *Rock 6809* (A, US); Tai-pon, *Maire 102* (A); Wei-si Hsien, *Tsai 59523, 59799, 63116* (A), *Wang 63709* (A); without precise locality, *Ducloux 132* (NY, UC), *Forrest 16241, 14510* (A), *Yu 5562, 5771* (A).

Celastrus gemmatus often has been confused with *C. orbiculatus* Thunb., since the two are closely related. After a careful examination of specimens of the two species, it was found that although their floral morphology is similar, *C. gemmatus* has larger conic axillary buds, firmly membranaceous and densely reticulated leaves, and, in addition, a distinct geographical distribution which separates it from *Celastrus orbiculatus* and other related species. *Celastrus gemmatus* is chiefly distributed in southwestern China and is rarely found in southeastern China; some plants are recorded as far north as Hupei which may represent its northern limit.

I have seen the types of *Embelia esquirolii* Lévl. and *C. lokchongensis* Masamune, They both bear large conical axillary buds and densely reticulated leaves, and are within the geographical range of *Celastrus gemmatus*. Hence, I consider these species as synonyms of *Celastrus gemmatus*.

17. CELASTRUS ORBICULATUS Thunb. Fl. Jap. pp. xlii, 97 (errore "*articulatus*"). 1784; Gmel. Syst. Veg. 406. 1796; Lam. Tab. Encycl. et Meth. Bot. 2:94. 1797; Airy Shaw, in Curtis's Bot. Mag. 158:*tab. 9394*. 1935. (T.: *collector unknown s. n.*, A, photo!).

Celastrus articulatus Thunb. Fl. Jap. 97. 1784 (sub. *Celastrus orbiculatus*, quoad nomen apud Thunb. in Fl. Jap. p. xlii); Maxim. in Bull. Acad. Sci. St.-Petersb., III, 27:456. 1881; Mel. Biol. Acad. St.-Petersb. 11:200. 1881.

Celastrus tatarinowii Rupr. in Bull. Acad. Sci. St.-Petersb., II, 40:357. 1857, ex char.

Celastrus punctatus sensu Regel, in Gartenfl. 9:407, *tab. 312, f. 6.* 1860, non Thunb.
Celastrus articulatus Thunb. var. *pubescens* Makino, in Bot. Mag. Tokyo 7:102. 1893, ex char. (T.: *Makino s. n.*).
Celastrus orbiculata Thunb. forma *β. microphylla* Loes. in Engl. Bot. Jahrb. 30:469. 1901, ex char. (T.: *Henry 3827*).
Celastrus orbiculata Thunb. forma *γ. maior* Loes. loc. cit. 30:469. 1901, ex char. (T.: *Giraldi 237*).
Celastrus articulata Thunb. var. *cuneata* Rehd. & Wils. in Sarg. Pl. Wils. 2:350. 1915. (T.: *Wilson 2308*, A!).
Celastrus lancifolia Nakai, in Bot. Mag. Tokyo 37:3. 1923, ex char. (T.: *Nakai s. n.*).
Celastrus insularis Koidz. in Bot. Mag. Tokyo 39:22. 1925, ex char. (T.: *Koidzumi s. n.*).
Celastrus strigillosus Nakai, loc. cit. 40:492. 1926, ex char. (T.: *Nakai s. n.*).
Celastrus articulatus Thunb. var. *stephanotiifolius* Makino, in Jour. Jap. Bot. 3:24. 1926, ex char. (T.: *Makino s. n.*).
Celastrus stephanotiifolius (Makino) Makino, loc. cit. 3:46. 1926.
Celastrus orbiculata var. *aureo-arillata* Honda, in Bot. Mag. Tokyo 45:422. 1931, ex char. (T.: *D. Shimisu 50*).
Celastrus jeholensis Nakai, apud Nakai & Kitagawa, in Rept. 1st. Scientif. Exped. Manchoukuo, Sect. IV, 1:6, *pl. 1.* 1934, ex char. (T.: *Nakai et al. s. n.*).
Celastrus articulatus var. *papillosus* Nakai ex Hara, in Jour. Jap. Bot. 10:84. 1934, ex char. (T.: *H. Hara s. n.*).
Celastrus articulata var. *orbiculata* (Thunb.) Wang, in Chin. Jour. Bot. 1:62. 1936.
Celastrus orbiculatus var. *papillosus* (Nakai) Ohwi, Fl. Jap. 736. 1953.
Celastrus versicolor Nakai, in Bull. Sci. Mus. Tokyo 33:16. 1953, ex char. (T.: *Nakai & Maruyama s. n.*).
Celastrus orbiculatus var. *pilosus* Nakai, loc. cit. 33:16. 1953, ex char. (T.: *Hozawa-Sigeo s. n.*).
Celastrus orbiculatus f. *papillosus* Nakai ex Hara, Enum. Spermat. Japon. 80. 1954.

Scandent shrubs up to 10 or 12 m. tall; branches terete to slightly striate, glabrous, light to darkish brown, the lenticels inconspicuous or sparse; axillary buds small, depressed, ovoid to subglobose, 1–3 mm. long, sometimes the outermost scales becoming deltoid, sharp-spinose, 1–2 mm. long. Leaves extremely variable in size and shape, usually obovate to suborbicular, ovate, or oval-oblong, the apex rounded, shortly cuspidate to acute, the base cuneate to obtuse, the margins crenate-serrate, 2–12 cm. long, 1.5–8.0 cm. wide, delicately membranaceous, glabrous above, rarely puberulent below, the primary lateral veins 3–6 pairs, distinctly elevated below, slightly elevated above, the veinlets slightly reticulated, prominent and slightly elevated below, immersed and obscure above; stipules filiform, tufted, about 1–2 mm. long; petioles 1–3 cm. long. Inflorescences axillary, rarely also terminal in the male plant, usually 3- to 7-flowered, occasionally solitary, often rather congested along the shoots of the current year, the subtending leaf sometimes not developed, distinctly pedunculate, the peduncles subequal, glabrous, the primary peduncles 3–8 mm. long; flowers yellowish-green, regularly dioecious, but occasionally monoecious in late growth, the pedicels about 2–3 mm. long, accrescent, the articulation usually at the base or lower third of the stalk. Male flowers: calyx lobes open, ovate-deltoid, subacute to obtuse, glandular-ciliolate, about 1.5 mm. long; petals narrowly oblong to oblanceolate, obtuse, subentire to slightly ciliolate or erose, usually 3–5 mm. long and 1–2 mm. wide; disc thin, cup-shaped, the lobes usually acute; stamens arising from the margin of the disc proper, about

3 mm. long, the filaments filiform, glabrous, the anthers oblong-ellipsoid, obtuse, pink-punctate; sterile pistil columnar, about 2 mm. long. Female flowers: calyx, petals, and disc as in the male, sometimes the petals smaller; sterile stamens about 1.3 mm. long; pistil flask-shaped, about 4 mm. long, the ovary ovoid, narrowed into a columnar style, the stigmata 3-lobed, the lobes flat, recurved, sometimes each slightly bifid. Fruits subglobose, bright yellow, the valves broadly elliptic to suborbicular, about 6–8 mm. long and 5–7 mm. wide, 3- to 6-seeded, the pedicels usually green in dry condition. Seeds usually ovoid or ellipsoid, about 5 mm. long and 3.5 mm. wide, minutely areolate, pinkish-brown.

Common in lowland slopes or in thickets, at altitudes from 100 to 1,400 m.; widely distributed in northern and central Japan, Korea, and China; flowering from April to June.

CHINA: CHEKIANG: Hai-wei, southern I-shing, *Ching & Tso 580* (A). HARBIN: (Pinkiang), along a river, *Skvortzov s. n.*, Dec. 7, 1929 (A). HONAN: Siashih, *Hers 345* (A); Sunghsien, Shih-tze-miao, *Hers 1272* (A); Teng-feng Hsien, Yu-tai Shan, *Hers 2791* (A); Tsi-yuan Hsien, *Hers 1758, 2795* (A); Yungning, Yu-tze-ping, *Hers 828* (A); without precise locality, *Hers 26* (A). HOPEI (CHILI): Ch'o-K'ou-tien, 50 km. sw. Peking, *Bohlin 104* (S, UPS); Chang-li, *Dorsett & Morse 7152* (US); western hills, *Dorsett & Morse 7206* (UC, US); Prince Park, *Wang 176* (NY); mont. á l'ouest Peking pagoda, Pi-yun-sen, *Janet 1639* (UPS); Haiao-wu-tai Shan, *Smith 740, 959* (S, UPS); Kuan-tso-ling, *Liu 1176* (UC); Ming Tombs, Nankou, *Chiao 2126* (US); Tsing-ling-chiao, *Chiao 2116* (NY), *Dorsett & Morse 7074* (US); near eastern Tombs, *Liou 385* (NY); western Tombs, *Liu 398* (UC); without precise locality, *Li 11169* (NY). HUPEI: Ichang, *Chun 3505* (A), *Wilson 2308* (A, holotype of *Celastrus articulata* var. *cuneata* Rehd. & Wils.); Noh-chen Hsien, *Chow 369* (NY); Lo-kia Shan, Wuchang, *Sun 108* (NY); western Hupei, without precise locality, *Wilson 181* (GH, US). JEHOL (GEHOL): *David 1783* (GH, US). KANGSU: Mien Shan, Lin-shih Hsien, *Tang 889* (A); Tienschui, *Fenzel 2827* (A). LIAONING: Liaoyang, Mukden, *Li 69* (UC). PORT ARTHUR: *Wilson 8801* (A). NANKING: *Ling 1402* (UC). SHANSI: Chioh-hsin Dist., *Smith 5745* (A, S, UPS), *7697* (A, UPS); Chin-yuan, *Ling 1607, 1664* (UC); Fu-ping, Tao-ho-tze, *Janet A348* (UPS); Fu-ping, Ta-wu-tai Shan, *Janet A349* (UPS); Hweihsien, Shansi border, *Hers 704* (A); Tsing-huy, *Janet A79* (UPS); Dao-hui-gou, Wenshui, *Wang 174* (GH); Yuan-chu Dist., Yang-shu-ling, *Smith 6154* (UPS). SHANGTUNG: Meng Shan, Fei Hsien, *Cheo & Yen 193* (A); Tsing-tao, First Park, *Chiao 2395* (A, NY, US), *2612* (A, F, NY, UC, US); Tsing-tao, *Lioent 13262* (A); Tsinan, Ching-lung Shan, *Chiao 3016* (A, NY, UC, US). SHENSI: Lao-y-san, *Giraldi s. n.*, June 5, 1897 (A, UC); Tai-pei-shan, *Purdom 944* (A, US), *945* (A); Tsingling-shan centr. inter Mei et Liupa, *Fenzel 502* (A).

JAPAN: HONSHU: Chiba Pref., Mobara, *Walker 5717* (US); Kanagawa, Hakone in Sagami, *Ohwi & Okamot 504, 506* (L, S, UC, US); Hakone, *Sawada 2161* (S); Mt. Tanzawa, *Suzuki 479013* (UC); Mino (Gifu), *Shiota 3899, 3905, 9643, 9766* (A); Prov. Musashi, *Hurusawa 10650* (MO), *Yamazala 44* (US); Prov. Nagano, *Kimura 307* (US), *Suzuki 455009* (UC); Niigata, Sado, *Faurie 2502* (MO); Nikuko, Shimotsuke, *Wilson s. n.*, 1914 (A); Otake-gawa, Shinano Prov., *Wilson s. n.*, 1914 (A); Suruga Prov., *Wilson 6907* (A, MO, US); Oku-shiobara, Tochigi, *Suzuki 444020* (UC); Tokyo, *Faurie 6134* (A), *Yamazala 44-A* (US); Kamohura, Sagami Prov., *Wilson 6627* (A, US); Kumashii, Tomari, Toyama, *Bergman 439* (S); Prov. Ugo, *Mizushima 1929* (MO); Mitsutooge, Yamanashi Pref., *Suzuki 486024* (UC); Mt. Hoowoo, Yamanashi, *Suzuki 493027* (UC). HOKKAIDO: Prov. Iburi, Zezo, *Takenauchi s. n.*, July 17, 1916 (S); Sapporo, *Faurie 6133* (A), *Jack s. n.*, Aug. 22, 1905 (A, GH), *Miyabe s. n.*, June 1880 (A, GH), *Wilson 7412* (A); vicinity of Obihiro, Tokachi, *Dorsett & Morse 1070* (A, US); southern Hokkaido,

without precise locality, *Brooks 44* (A, UC), *544* (UPS). KURILE ISLANDS: Shikotan, *Ohwi 436* (UPS). WITHOUT PRECISE LOCALITY: *Thunberg s. n.* (A, type photo of *C. orbiculatus, pl. 961*).

KOREA: Port Chusan, Keisho Nan, *Wilford s. n.*, 1859 (GH, S); Port Hamilton, *Wilford s. n.*, 1859 (GH, S); Keijo (Seoul), *Mills s. n.*, Oct. 2, 1915 (UC); Kongo-san, Prov. Kogen, *Wilson 10461* (US); Pyongang, *Wilson 9203* (US); Taiyudo Prov., Hsian Hoku, *Wilson 8611* (US); without precise locality, *Gilbert 6* (UC).

Thunberg describes this species (Fl. Jap. p. 97, 1784) as *Celastrus articulatus.* However, in his index, p. xlii, *articulatus* is omitted and *orbiculatus* is listed. In 1796, Gmelin[32] used the name *orbiculatus* and referred to Thunberg's Fl. Jap. p. 97, but he did not mention *articulatus.* Later, in 1881, Maximowicz pointed out[33] that the name *articulatus* was due to a printer's error, having been changed from *C. orbiculatus*, as shown in the 'Flora Japonica' and the figures of Thunberg's manuscript. However, Maximowicz chose *Celastrus articulatus* as the species name because it was universally accepted at that time. Airy Shaw[34] states in 1935 that "The form *articulatus* is a 'vain tradition', and the sooner it is dropped the better—but tradition dies hard!" I agree that it is best to use the originally correct name for this species, even more so because "orbiculatus" refers to the leaf shape.

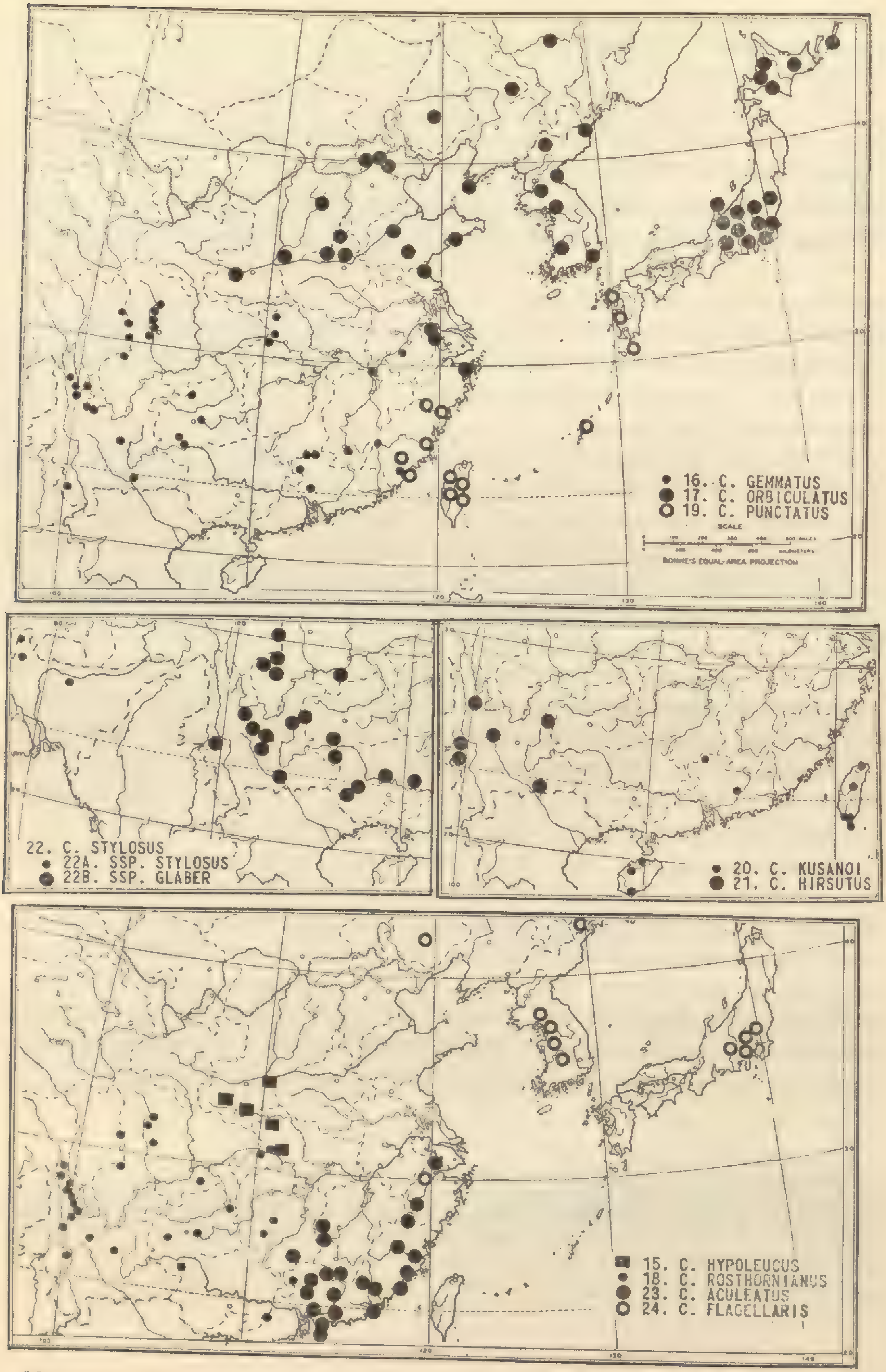
This is a very widely distributed eastern Asiatic species. It is found in northern and central Japan, and provinces north of the Yangtze River in China. The Yangtze River seems to be the southern limit of its distribution, except for a few specimens that have been collected south of the river (northern Chekiang).

It is the commonly cultivated and nearly naturalized exotic *Celastrus* of the eastern United States where it was introduced at the New York Botanical Garden in 1891 from seeds secured from the Royal Botanic Gardens, Kew[35]. The fruit-clusters are axillary and remain attractive through the winter after the leaves have fallen; the fruiting branches are as showy as those of the paniculiform *Celastrus scandens.* Birds are fond of the ripe seeds[36] and help to propagate them.

I have observed two living plants of this species cultivated in the Missouri Botanical Garden. In the spring both have male flowers; all the floriferous branches bear both axillary and terminal inflorescences. In June, the male flowers fall, and the terminal inflorescences fall away from the plant; some of the axillary buds or buds that are near the top of the branchlets sometimes now develop into shoots which bear only female flowers. Some of the female flowers develop into fruits which in these plants are scarce. The leaves are variable. Due to the variation caused by these characteristics, there are many synonyms for this species.

---

[32] Syst. Veg. p. 406. 1796.
[33] Mél. Biol. Acad. St. Pétersb. 11:201. 1881.
[34] Curt. Bot. Mag. 158:*tab. 9394.* 1935.
[35] Nash, C. V. *Celastrus articulatus.* Addisonia 4:9–10, *pl. 125.* 1919.
[36] Burbidge, F. W. Japanese tree-strangler, or staff tree *(Celastrus articulatus).* Gard. Chron. III, 23:28, *f. 11.* 1898.



Map 3. Distribution of ten species of *Celastrus*, Subgenus CELASTRUS, Series II. AXILLARES.

18. CELASTRUS ROSTHORNIANUS Loes. in Engl. Bot. Jahrb. 29:445. *tab. V. F-H.* 1900. (T.: *Rosthorn 1572*, A, photo!).

Celastrus stylosa sensu Lévl. Fl. Kouy-Tchéou, p. 69. 1914, non Wall.
Celastrus loeseneri Rehd. & Wils. in Sarg. Pl. Wilson. 2:350. 1915. (T.: *Wilson 357*[a], A!).
Celastrus cavaleriei Lévl. in Monde des Pl. II, 18:31. 1916. (T.: *Cavalerie 496*, A, photo!), non Lévl. 1914.

Scandent shrubs up to 7 m. tall; branches terete, occasionally striate, glabrous, gray-brown to brown-red, densely to sparsely lenticelled, the lenticels elevated, ovate; axillary buds ovoid, about 3 mm. long. Leaves elliptic, oval, or obovate-oblong, the apex acute, the base cuneate to obtuse, the margins remotely serrulate to serrate, usually 4–11 cm. long, 2–6 cm. wide, thinly membranaceous on the flowering specimens, firmly membranaceous on the fruiting specimens, glabrous, the primary lateral veins 4–7 pairs, prominent, slightly elevated on both surfaces, the veinlets obscure on both surfaces; stipules filiform, tufted; petioles 0.5–1.5 cm. long. Inflorescences axillary as well as terminal in the male plants, axillary only in the female, the terminal portion sometimes up to 5 cm. long, usually fascicular, rarely solitary; peduncles glabrous, the primary peduncles very short to nearly obsolete in the fascicular inflorescences, 2–5 mm. long at the solitary ones; flowers dioecious, yellowish-green, the pedicels 2–5 mm. long, the articulation at the middle or lower half of the stalk. Male flowers: calyx lobes valvate, ovate to oblong, obtuse, subentire or glandular-ciliate, about 3 mm. long and 1 mm. wide; stamens arising from the margin of the disc proper, 2.5 mm. long, the filaments filiform, glabrous, the anthers ovoid, obtuse, slightly brownish-punctate; sterile pistil subulate columnar, about 1.5 mm. long. Female flowers: calyx lobes, petals, and disc as in the male; sterile stamens about 1.3 mm. long; pistil about 3.5 mm. long, the ovary subglobose, the style about 1.8 mm. long, the stigmata 3-lobed, each deeply bifid, filiform. Fruits subglobose, the valves broadly elliptic, about 7 mm. long and 6 mm. wide, 3- to 6-seeded; seeds ovoid or ellipsoid, about 4 mm. long and 2 mm. wide, the areolae distinct, yellowish-brown.

Chiefly in thickets, at altitudes from 400 to 3,400 m.; China; flowering from April to May.

CHINA: HUPEI: Bo-moh-ping, *Chun 3570* (A); Changyang, *Wilson 688* (A), *706* (NY); Hsing-shan Hsien, *Wilson 357*[a] (A, type of *Celastrus loeseneri* Rehd. & Wils.; GH, MO), *560*, *2309* (A, US), *Chen 1090* (UC); Kui, *Wilson s. n.*, June 1907 (NY); Patung Hsien, *Ho-chang Chow 315*, *572* (A, NY), *Wilson 503* (A, US); without precise locality, *Henry 315* (A, GH), *5909* (GH, NY, US). HUNAN: Hsikwang Shan, *Handel-Mazzetti 583* (A); Hsinhwa, *Handel-Mazzetti 810* (A); Wukang, *Te-Hui Wang 114* (A). KWANGSI: Lin-yuin Hsien, *Steward & Cheo 429* (A, NY); Ling Wun, *Lau 28207*, *28763* (A); Ling-yun Hsien, *Lau 28558* (A). KWANGTUNG: Suny, *Wang 32148* (A); Yang-shan Hsien, *Tsui 542* (A, MO, UC, US). KWEICHOW: Anlung, *Tsiang 9354* (A, NY); Kiang-kow, *Tsiang 7499* (A, NY); Kweiting, *Tsiang 5443* (A, NY), *5614* (A); Lang-tai, Yeh-tin, *Tsiang 9513* (A, NY); Wai-ho, near Sio-chang, *Tsiang 5601* (A); without precise locality, *Cavalerie 496* (type of *Celastrus cavaleriei*, photo, A). SIKANG: near San-tao-chiao, 40 li from I-tung, *Chiao 1720* (A); Konting (Tachien-lu), *Wilson 4187* (A); Tienchuan, *Fang 3424* (A), *3486* (A, NY). SZECHUAN: Chao-hua Hsien, *Hopkinson 297* (S); Chengtu, *Chien 5920* (A), *Feng 19884* (A); Chin-ting Shan, *Wilson 2311* (A); inter Kuapie et Tahao-ko, *Schneider 1375* (A); Mian-ning

Hsien, *Yu 1756* (A); Mow Hsien, *Fang 5589* (A, NY); Nan-chuan, *Rosthorn 1572* (type, photo of *Celastrus rosthornianus*, A), *1753* (A, paratype of *C. rosthornianus*); Ning-yuen, *Handel-Mazzetti 1305* (A); Telipu, *Schneider 1131* (A); Tien-chuan, *Yu-shih Liu 1319* (A); Wen-chuan Hsien, *Wilson 1175* (A, US), *4159* (A); inter flumina Yalung et Nganning-ho, *Handel-Mazzetti 2008* (US); Omei Shan, *Chow 5707* (A), *Chow 11742, 12013* (A), *Chu 3701* (A), *Fang 16419, 17795* (A), *Lee 2805* (A), *3069* (A, US), *Wilson 4781* (A); without precise locality, *Faber 227* (NY), *Henry 5640* (A, GH, MO), *5734* (GH, NY). YUNNAN: A-tun-tze, *Wang 69361* (A), *Yu 7978* (A); Chung-tien, *2428, 2479, 3262* (A); La Kou, *Maire 3633 ser. B* (A, NY, UC); Lapping Hsien, *Tsai 56096* (A); Liang-shan, *Tsai 51340, 51343* (A); Likiang, *Ching 22119* (A), *Forrest 21201* (A, US), *Rock 3885* (A, US), *8312* (NY, UC, US); Mar-li-po, *Feng 13124, 13369* (A); Mekong, *Rock 6946* (A, UC, US); Mienning, Poshang, *Yu 17893* (A); Muli, near Lama-sery, *Yu 14848* (A); Pan-pien-kai, *Maire 7256* (UC); Pin-chuan Hsien, *Tsai 52901* (A); Ping-pien Hsien, *Tsai 60781* (A); Si-chour Hsien, *Feng 11720, 12084* (A); Shun-ning, *Wang 71910* (A); Suen-oui, *Maire 81* (A); between Sung-kweh and Tengchuan, *Schneider 2683* (A, GH, NY); Tso-si, *Maire 254* (A); Wei-se Hsien, *Tsai 57974, 59548, 61753, 63059, 64147, 68293* (A); without precise locality, *Forrest 7812, 16226* (A); *Tsai 57253, 57271, 57343, 57510, 57769, 60933* (A); *Yu 5185, 7204, 5845* (A).

This is a common species chiefly distributed in southwestern and central China. Since the leaf characters are quite variable, this species has sometimes been misidentified. However, the characters of the flower, fruit, and seed are constant. The racemiform inflorescences bear clustered, usually sessile flowers; the disc-lobes are subquadrate, broader than long, and mucronate; and the seeds are ovoid or ellipsoid and usually yellowish-brown. These characters can distinguish *Celastrus rosthornianus* from related species.

Léveillé first identified a specimen collected by Cavalerie (no. *496*) from Kweichow as *Celastrus stylosa* Wall., and later described it as a new species *C. cavaleriei* (non *Léveillé 1914*) although he had previously published the same name based on another specimen. The earlier name subsequently was shown by Rehder[37] to be a *Myrsine*. I have seen the type photo of the *Cavalerie 496* specimen, and it compares closely with others collected in Kweichow. They are all fruiting specimens, and clearly belong to *Celastrus rosthornianus*. These Kweichow plants have grayish-brown, striate-fissured branches, and remarkably uniform, elliptic, firmly membranous leaves. This uniform population perhaps could be considered as an ecotype.

19. Celastrus punctatus Thunb. Fl. Jap. 97. 1784. (T.: *Collector unknown, s. n.*, A, photo!).

Celastrus scandens sensu Thunb. in Trans. Linn. Soc. 2:332. 1794, non L.
Celastrus punctulatus in Abh. Bayer. Akad. Muench. II, 4:150. 1845 (apparently an error for *punctatus*).
Celastrus crispulus Regel, in Gartenfl. 9:407, *tab. 312, f. 1–5.* 1860, ex char. & ill.
Celastrus striatus Miq. in Ann. Mus. Bot. Lugd.-Bat. 2:210. 1865–66, non Thunb., ex char.
Celastrus kiusianus Franch. & Sav. Enum. Pl. Jap. 2:314. 1879, ex char. (T.: *Savatier 3528*).
Celastrus orbiculatus var. *punctatus* (Thunb.) Rehd. in Bailey, Cycl. Am. Hort. 1:267. 1900.
Celastrus articulatus Thunb. var. *punctatus* (Thunb.) Makino, in Bot. Mag. Tokyo 21:138. 1907.

[37] Jour. Arn. Arb. 15:292. 1934.

Celastrus gracillimus Hay. Icon. Pl. Formosa. 5:24. 1915. (T.: *Hayata s. n.* A, photo!).
Celastrus leiocarpus Hay. loc. cit. 5:22. 1915. (T.: *Mori s. n.*, A, photo!).
Celastrus longe-racemosus Hay. loc. cit. 5:23, *pl. 3.* 1915. (T.: *Hayata s. n.*, TAI!).
Celastrus geminiflorus Hay. loc. cit. 5:25, *f. 9.* 1915. (T.: *Nagasama s. n.*, A, photo!).
Celastrus elevativenus Hay. loc. cit. 6:14. 1916. (T.: *Faurie s. n.*, A, photo!).
Celastrus punctatus Thunb. var. *microphyllus* Li & Hou ex Hou, in Taiwania 1:172. 1950. (T.: *Yamamoto 802*, TAI!).

Scandent shrubs, about 2–3 m. tall; branches terete, glabrous, hazel-brown, the lenticels rounded or oval, scattered and elevated; axillary buds deltoid, about 2 mm. long, the outermost bud scales sometimes sharply spinose. Leaves usually elliptic, the apex acute, the base usually cuneate, the margins remotely serrate, 2–7 cm. long, 0.8–3.0 cm. wide, membranous, glabrous, the primary lateral veins 4–5 pairs, slightly elevated below, immersed above, the veinlets obscure to distinct; stipules filiform, tufted, about 2 mm. long; petioles about 0.5–1.0 cm. long. Inflorescences axillary as well as terminal in the male plant, axillary only in the female, fasciculate, racemiform, or solitary, the peduncles obsolete, glabrous, the primary peduncles suppressed to about 5 mm. long; flowers dioecious, white or pale green, the pedicels 1.0–1.5 mm. long, the articulation at the middle or upper third of the stalk. Male flowers: calyx lobes open, deltoid to oblong, obtuse, glandular-ciliate, about 1 mm. long; petals usually oblong to slightly obovate-oblong, ciliate to slightly erose, 2.5–4.5 mm. long and 1.3–1.5 mm. wide; disc cupuliform, the lobes erect, oblong, about half to one-third as long as the disc proper, obtuse; stamens arising from the margin of the disc proper, the filaments filiform, glabrous, the anthers broadly ovoid, obtuse, the base divided to above the middle, pink-punctate; sterile pistil subconical-columniform, slightly 3-lobed, about 1.5 mm. long. Female flower unseen. Fruits globose or subglobose, usually solitary, fasciculate, sessile or occasionally short-pedunculate, pale yellow when dried, the valves suborbicular, about 6 mm. in diameter, 3- to 6-seeded; seeds broadly ellipsoid, about 2 mm. long, smooth, pinkish-brown.

Hillsides and in thickets, at altitudes from 100 to 2350 m.; southeastern China, Riukiu Islands, and southern Japan; flowering from March to August.

CHINA: ANHWEI: Chu-hwa Shan, *Ching 2661* (UC). CHEKIANG: Changhua, *Keng 567* (A, UC); south of Siachu, *Ching 1677* (MO, NY, UC, US). FUKIEN: Amoy, *Chung 493* (SING), *1437, 1447, 1491* (A, UC), *1515* (UC), *4604* (A, NY), *5957* (A); Diongloh, *Ping En Chen 2447, 2701* (UC), *Siu Ging Tang 13657* (UC); Foochow, *Siu Ging Tang 1677, 7085* (A, UC); Kushan, *Dunn 44* (A); Mt. Useke, *Nagasawa s. n.* (A, photo of type of *C. geminiflorus*). TAIWAN: Arisan, *Gressitt 141* (A, L, NY, S, U), *185* (A, L, NY, S, U), *Hayata s. n.*, April 26, 1914 (TAI, photo of type of *C. longe-racemosus;* A), *s. n.* (A, photo of type of *C. gracillimus*); Nanko-taisan, *Sasaki s. n.*, July 22, 1922 (A, photo); Kwarenko, *Faurie s. n.* (A, photo of type of *C. elevativenus*), *Nakamura 3618* (TAI); Shinchow, Prov. Karenko, *Wilson 11096* (A, US); Taito, *Mori s. n.* (A, photo of type of *C. leiocarpus*); Mt. Taito, *Yamamoto 802* (type of *C. punctatus* var. *microphyllus*, TAI).

JAPAN: KYUSHU: Mt. Kirishima, *Tashiro s. n.*, May 5, 1917 (A); Kudsi Kadsura, *Tsuro Ome* (?) *500* (A); Nagasaki, *Oldham 161* (GH, L, S), *162* (GH), *Wilson 6304* (A); Satuma, *Suzuki s. n.*, Aug. 13, 1930 (TAI); Tanegashima, Kita-tane, *Mori s. n.*, Aug. 13, 1934 (TAI); Tanaga-shima, *Wilson 6121* (A).

RIUKIU ISLANDS: *Wright 54* (GH).

The type of *Celastrus longe-racemosus* is a flowering specimen whereas the type of *C. punctatus* var. *microphyllus* is a fruiting specimen. Until now no fruiting or flowering specimens, respectively, for these two species have been found. On further examination of additional specimens, it was observed that the fruiting branchlets of the type of *C. punctatus* var. *microphyllus* are the same as the so-called long-racemose inflorescences of *C. longe-racemosus;* consequently, they appear to belong to the present species because they cannot be distinguished from it. On comparing material from Fukien and southern Japan, this interpretation is confirmed by both morphological characters and geographical distribution.

In general appearance, the present species differs conspicuously from *Celastrus orbiculatus* and more closely resembles *C. rosthornianus.* However, the deeply cleft, oblong disc lobes, the articulations located at the upper third or half of the stalk, as well as the distinct geographical distribution distinguish this species from related ones.

20. Celastrus kusanoi Hayata, in Jour. Coll. Sci. Imp. Univ. Tokyo 30:60. 1911; Icon. Pl. Formos. 1:137. 1911; 5:20. *t. 8.* 1915, ex char. & ill. (T.: *Kusano s. n.*).

Scandent shrubs up to 18 m. tall; branches terete, sometimes striate, brown, the branchlets glabrous to brownish-pubescent, both sparsely or rarely densely lenticelled, the lenticels orbicular or ovate; axillary buds deltoid, about 2.5 mm. long. Leaves broadly elliptic to nearly orbicular, rarely elliptic, the apex rounded to shortly cuspidate, the base broadly truncate, rarely obtuse to cordate, 5.0–10.5 cm. long, 5–11 cm. wide, chartaceous, glabrous or pubescent on the veins below, the primary lateral veins 5–7 pairs, slightly elevated on both surfaces, the veinlets distinct below, obsolete above; petioles usually 1.5–2.5 cm. long, rarely up to 5 cm. long; inflorescences axillary and cauline at the basal position of the current year's growth, rarely also terminal in the male plant, usually 3- to 7-flowered, the peduncles usually pubescent, sometimes yellow, the pedicels about 3–5 mm. long, usually pubescent, the articulation nearly toward the base of the stalk. Male flowers: calyx lobes deltoid, obtuse, entire, about 1 mm. long; petals obovate to oblong, rounded, about 4 mm. long and 1.5 mm. wide, ciliate, sometimes pubescent within on the lower portion; disc subfleshy, flat, the lobes obscure, truncate; stamens arising from the margin of the disc, about 3 mm. long, the filaments filiform, papillose-tuberculate, the anthers ovoid, subcordate; sterile pistil conical, about 1 mm. long. Female flowers: calyx, petals, and disc as in the male; sterile stamens about 1.5 mm. long; pistil about 3.3 mm. long, the ovary subglobose, the style columnar, the stigmata 3-lobed, reflexed. Fruits globose or subglobose, the valves suborbicular or broadly elliptic, about 8–10 mm. long and 5–7 mm. wide, 3- to 6-seeded; seeds slightly lunate, minutely areolate, dark brown.

Chiefly in thickets, at altitudes from 100 to 1,000 m.; southeastern China; flowering from February to April.

China: hainan: Bak Sa, *Lau 26184, 26606* (A); Ching-mai Hsien, *Lei 309* (A, NY, SING, UC, US); Fan Yah, *Chun & Tso 44028* (A, F, NY, US). kwangtung:

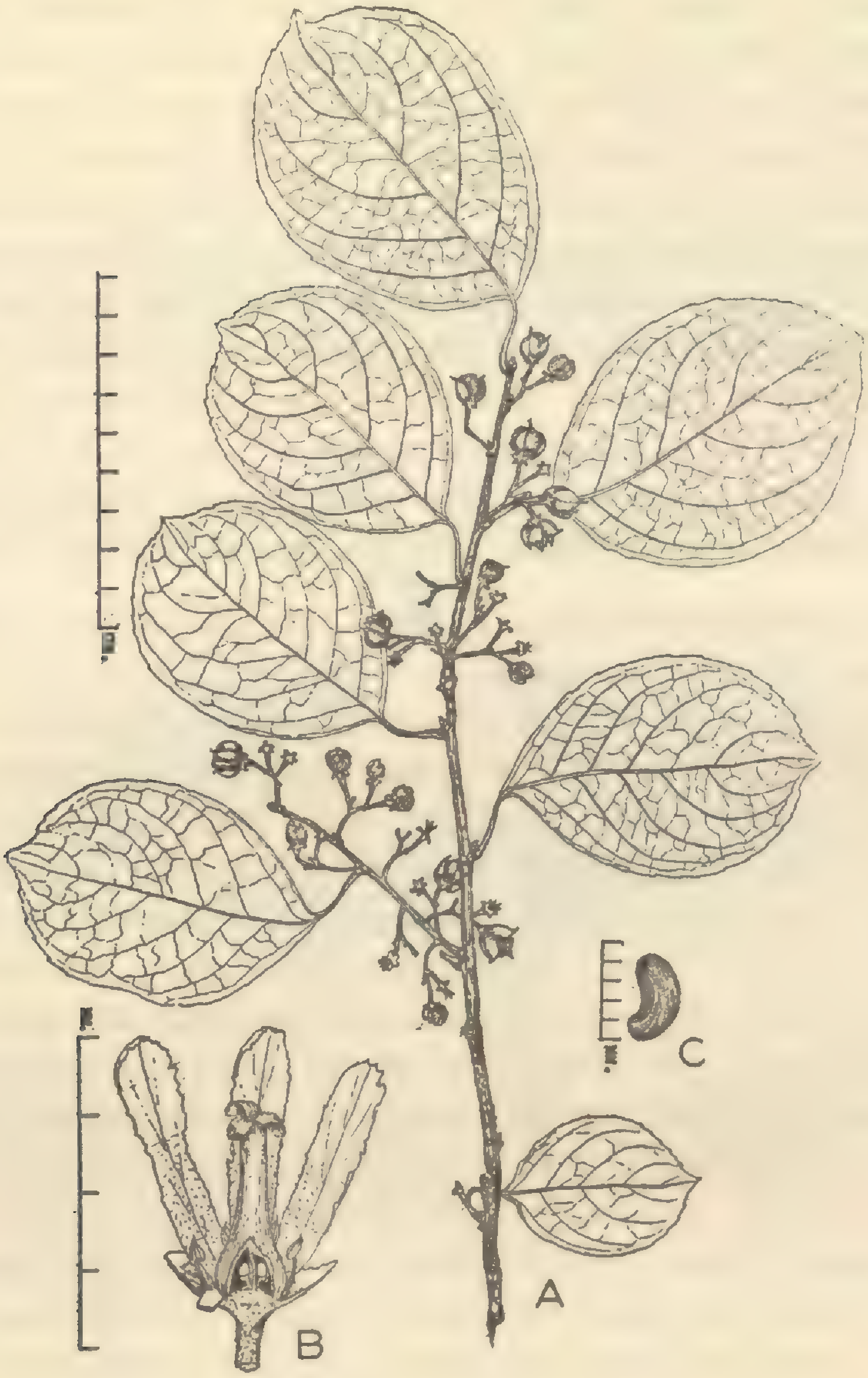


Fig. 10. *Celastrus kusanoi* Hayata

Lokchong, *Tsiang 1393* (A, UC), *Tso 20788, 20796, 21026* (NY); Tsinleong Shan, Mei Hsien, *Gressitt 1240* (A, MO); Lung-t'au Shan, Iu village, *Kang-peng To 131* (UC), *442* (MO, UC); Nam Shan, Ho-yuen Hsien, *Tsang 28927* (A); Ying-tak, *Kang-peng To & Kam-chow Wong 2784, 2928* (UC). TAIWAN: Arisan, *Faurie 1374* (A); Kosyun, *Kudo & Suzuki 16048* (TAI), *Suzuki 6195* (TAI); Kuaru, *Yamada 1215* (TAI); Mt. Naier, Bansyoryo, *Kawakami & Mori 3145* (TAI); Nanto, *Wilson 9981* (A); Taipei, *Wilson 11214* (A); Takou, Apes Hill, *Henry 1893* (A, NY, TAI).

Henry[38] first regarded the Formosan specimen, collected by himself (no. *1893*), as a variety of *Celastrus articulatus* Thunb., but did not give it a name. Later Hayata described a specimen collected by Kusano as *Celastrus kusanoi* Hayata, but he did not cite Henry's specimen. He stated that *Celastrus kusanoi* is near *C. articulatus (C. orbiculatus)* but differs from it in having more rounded leaves and

[38] A List of Plants from Formosa. p. 27. 1895.

carpels transversely wrinkled in the dried condition. His original description was based on a fruiting specimen; later[39] he obtained a flowering specimen, and then amplified his description. *Celastrus kusanoi* bears pubescent filaments, lunate seeds and usually nearly rounded leaves, hence it is easily distinguished.

Specimens collected from central and southern Formosa have nearly rounded and sometimes even cordate leaves, whereas those from Hainan and Kwangtung usually bear suborbicular or broadly obovate leaves without cordate bases.

Merrill and Chun[40] have said that Kwangtung records of *Celastrus articulatus* Thunb. (*C. orbiculatus* Thunb.) actually belong to *C. kusanoi* Hay. and that Thunberg's species does not extend as far as Kwangtung. Of the many Kwangtung specimens labelled *Celastrus articulatus* which I have examined, none of them actually is that species; they are either *Celastrus kusanoi* Hay. or *C. gemmatus* Loes.

21. Celastrus hirsutus Comber, in Notes Roy. Bot. Gard. Edinb. 18:233. 1934, ex char. (T.: *Forrest 17963*).

Scandent shrubs up to 12 m. tall; branches terete or slightly compressed, sometimes more or less sulcate, densely brownish-pubescent or glabrescent, the lenticels elevated, large, ovate, elliptic or orbicular, rarely lacking on the current year's growth; axillary buds ovoid, usually about 3 mm., rarely 5 mm., long, the bud scales accrescent, sometimes persistent. Leaves broadly ovate to obovate, the apex round, shortly cuspidate, the base rotund or broadly cuneate, the margins crenate-serrate, 7–14 cm. long, 4–10 cm. wide, membranous, densely pubescent on both surfaces especially so on the veins when young; primary lateral veins 6–7 pairs prominently elevated below, slightly elevated above, the veinlets distinct below, immersed to obscure above; stipules laciniate, about 1 mm. long; petioles pubescent, about 1.5–3.0 cm. long. Inflorescences axillary and cauline at the basal portion of the flowering branch, usually 7- to 14-flowered, the peduncles hirsute, the primary peduncles 5–15 mm. long; flowers dioecious, creamy-white to greenish-yellow, the pedicels 3–5 mm. long, the articulation toward the base of the stalk. Male flowers: calyx lobes valvate, deltoid, obtuse, sparsely ciliate and pubescent without, about 1 mm. long; petals obovate-oblong, puberulous at the basal portions of both surfaces, about 3.5 mm. long and 2 mm. wide, obtuse, slightly erose; disc membranous, slightly concave, the lobes arcuate, distinct; stamens arising between the disc lobes, about 2.5–3.5 mm. long, the filaments subulate, papillose-tuberculate, the anthers ovoid, obtuse, cordate; sterile pistil small, ovoid, about 1.3 mm. long. Female flowers: calyx lobes, petals, and disc as in the male; sterile stamens about 1 mm. long; pistil 3–5 mm. long, the style columnar, the stigmata conspicuously 3-lobed. Fruits subglobose, the valves broadly elliptic, about 8–10 mm. long and 6–8 mm. wide, 3- to 6-seeded; seeds slightly lunate, attenuate toward both ends, about 5 mm. long and 1.5 mm. wide, blackish-brown, the areolae distinct.

---

[39] Icon. Pl. Formos. 5:20. 1915.
[40] In Sunyatsenia 5:111. 1940.

Fig. 11. *Celastrus hirsutus* Comber

In thickets, at altitudes from 1,400–2,500 m.; China, Burma, and Indo-China; flowering from March to April.

BURMA: Adung valley, 27°30′ to 28°30′ lat., and 97°30′ to 98°30′ long., *Kingdon Ward 9362* (A).
CHINA: YUNNAN: Kengma, *Yu 17294* (A); Liukiang, Muchietu, *Yu 21012* (A); Makwan Hsien, *Tsai 51945* (A); Mar-li-po, Sze-tai-po, *Feng 13765* (A); Mienning, *Yu 17952* (A); Ping-pien Hsien, *Tsai 55421, 60261, 60499, 62396* (A); Shang-pa Hsien, *Tsai 54799* (A); without precise locality, *Forrest 17496* (A).
INDO-CHINA: Chapa, Tonkin, *Pételot 5936* (A, NY).

The particularly dense pubescence on both surfaces of the leaf makes *Celastrus hirsutus* easily recognized and distinguished from other species of the genus. On the other hand, as Comber previously has pointed out, its floral characters are quite similar to *Celastrus kusanoi* Hay. Specimens of these two entities indicate that although their floral characters are similar, their geographical distributions and

leaf and lenticel characters are distinct. For these reasons I am considering them as two separate species.

22. Celastrus stylosus Wall. in Roxb. Fl. Ind. ed. Carey 2:401. 1824; Wall. Cat. 4313. 1831; Lawson, in Hook. Fl. Brit. Ind. 1:618. 1875 (pro parte); Prain, in Jour. Asiat. Soc. Bengal 73:198. 1904. (T.: *Wallich 4313*, MO, photo!).

Scandent shrubs, 3–4 m. tall; branches terete, glabrous or puberulent on the branchlets, light brown to dark brown, sparsely lenticelled, the lenticels small, elliptic or ovate; axillary buds globose or ovoid, about 2 mm. long. Leaves usually elliptic-oblong, ovate to obovate, the apex acute, the base acute or obtuse, the margins serrate, 6–15 cm. long, 3–9 cm. wide, membranous to firmly membranous, glabrous or rarely pubescent on the veins below, the primary lateral veins usually 5–7 pairs, distinctly elevated below, plane or slightly elevated above, the veinlets prominent below, obscure to visible above; stipules filiform, about 1 mm. long; petioles usually 1–2 cm. long. Inflorescences axillary and cauline, usually 3- to 7-flowered, at the basal part of the current year's growth (rarely also terminal in the male plant of *Celastrus stylosus* ssp. *stylosus*), distinctly pedunculate; the peduncles puberulous to glabrous, the primary peduncles 5–11 mm. long; flowers dioecious, green or pale green, the pedicels 2–5 mm. long, the articulation toward the base of the stalk. Male flowers: calyx lobes imbricate, oval to oblong, obtuse, slightly erose to entire, about 1.5 mm. long; petals obovate, obtuse, slightly erose, about 2–4 mm. long and 1.0–1.5 mm. wide; stamens arising between the disc-lobes, about 2.5 mm. long, the filaments filiform, fleshy, glabrous to papillose-tuberculate, the anthers ovoid, cordate; disc membranous, cup-shaped, the lobes distinctly arcuate or depressed-quadrate; sterile pistil about 1.5 mm. long. Female flowers: calyx lobes, petals, and disc as in the male; sterile stamens about 1 mm. long; pistil flask-shaped, about 3 mm. long, the ovary subglobose, the style distinctly columnar, the stigmata 3-lobed, each lobe bifid, flat, reflexed. Fruits subglobose, the valves broadly elliptic, about 7–12 mm. long and 5–10 mm. wide, 3- to 6-seeded; seeds more or less plano-convex to slightly lunate, attenuate at both ends, reddish- to blackish-brown, about 4–6 mm. long and 1–2 mm. wide, the areolae distinct.

KEY TO THE SUBSPECIES

A. Staminal filaments always densely papillose-tuberculate; the disc-lobes depressed-quadrate; leaves elliptic, membranous. India ....22a. ssp. *stylosus*

AA. Staminal filaments usually glabrous, rarely sparsely papillose-tuberculate; the disc-lobes arcuate; leaves usually elliptic-oblong, firmly membranous. China............22b. ssp. *glaber*

22a. Celastrus stylosus ssp. stylosus.

Celastrus neglecta Wall. Cat. 4341. 1831, nom. nud.

Gymnosporia neglecta Wall. ex Lawson, in Hook. Fl. Brit. Ind. 1:619. 1875; Prain, in Jour. Asiatic Soc. Bengal 73:198. 1904, Novic. Ind. 419. 1905. (based on *Celastrus neglecta* Wall., *Wallich 4341*).

In thickets, at altitudes from 1,000 to 2,745 m.; India; flowering from March to July.

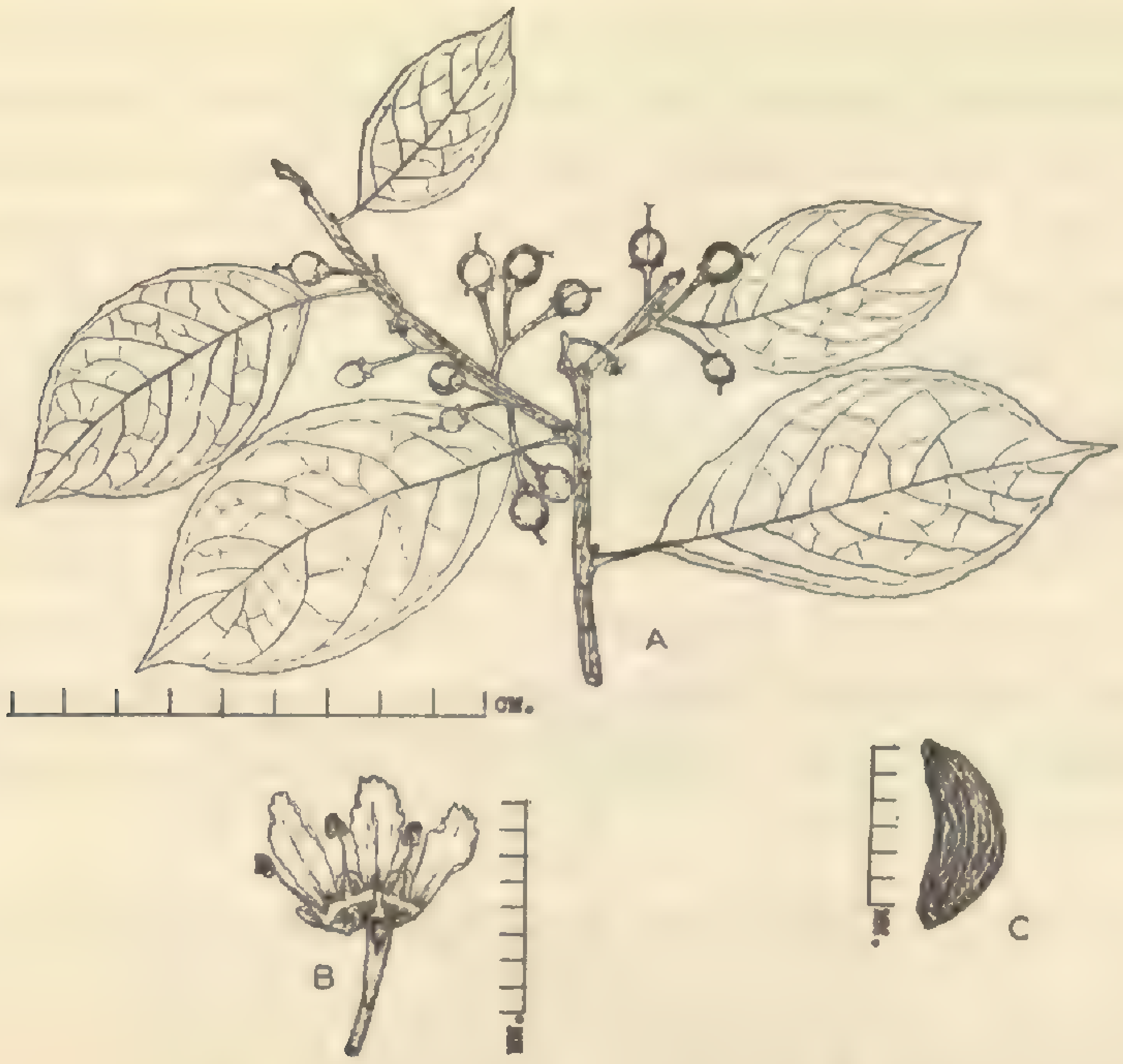


Fig. 12. *Celastrus stylosus* ssp. *stylosus*

INDIA: ASSAM: Khasi, *Kurz 171* (CAL), *Clarke 18678*^{C} (CAL). BENGAL: Darjeeling, *Boswastore 73* (CAL), *Clarke 26701*^{B} (CAL), *Kurz s. n.* (CAL). SIKKIM: Duphla Hills, *Lister 157* (CAL); Lachen, *Smith & Cave 964* (CAL); Moughoo, *Lister s. n.*, March 1878 (CAL); Punkabari, *Lister s. n.*, April 1878 (CAL); Singolila forest, *Rogers s. n.*, Jan. 1900 (CAL); Sureil, *Dr. Prain's collector 439* (CAL). WITHOUT PRECISE LOCALITY: *Anderson 104* (CAL); *Meebold 15912* (S).

22b. CELASTRUS STYLOSUS ssp. **glaber** Ding Hou, stat. et nom. nov.

Celastrus hypoleucus forma γ. *puberula* Loes. in Engl. Bot. Jahrb. 29:445. 1900. (T.: *Rostborn 1556*^{b}, A, photo!).
Celastrus crassifolia Wang, in Chin. Jour. Bot. 1:62. 1936; in Contr. Bot. Surv. N. W. China 1:62. 1939. (T.: *Yu 445*, A!).

Chiefly in thickets, at altitudes from 800 to 2,000 m.; China and Indo-China; flowering in April.

CHINA: ANHWEI: Kimen, *Ip 41* (UC); *Ching 3165* (UC); Wong Shan, *Ling 1104* (UC). KWANGSI: Chuen Yuan, *Tsoong 82041* (A); Kwei-lin Hsien, *Tsang 38365* (US); Ling-yuin Hsien, *Steward & Cheo 87* (A, NY, S, SING), *396* (NY, S); Nanning, Seh-feng-dar Shan, *Ching 8205* (NY, UC, US); Shang-sze Hsien, *Tsang 24131* (A, MO); Pin-lam, *Ko 55544* (A); Tsin-hung Shan, Hin Yen, *Ching 7080* (A, US). KWEICHOW: Mapo, Pingchow, *Tsiang 6832* (A, NY). SIKANG: Tien-chuan Hsien, *Tai & Feng 5238* (A). SZECHUAN: Nan-chuan, *v. Rostborn 1556*^{b} (A, photo of type of *C. hypoleuca* forma γ. *puberula*); Omei Shan, *Fang 15211, 15280* (A), *Lee 3168* (A), *Yu-shih Liu 1184* (A), *Yu 445* (A, type of *C. crassifolia*); Wa-shan, *Wilson 1184* (A); without precise locality, *Henry 5559* (A, GH). YUNNAN: Chungtien, *Feng 3365* (A); Hokin, *Feng 747* (A); Lung-ling Hsien, *Tsai 54563, 54578* (A); Mar-li-po, Chung-dzia, *Feng 12727* (A); Mengtze, *Henry 10522, 11267* (A, MO); Ping-pien Hsien, *Tsai 60420, 60019, 61156, 61629* (A); Shang-pa Hsien, *Tsai 54029* (A); Shunning, Wumulung, *Yu 16592* (A); Si-chour Hsien, *Feng 12260, 12283* (A); without precise locality, *Forrest 9396, 15980* (A), *Li 1181* (A), *Tsai 62841* (A).

INDO-CHINA: Chapa, Tonkin, *Pételot 5829, 5946* (A, NY, US).

These two subspecies are superficially similar except for the staminal filaments, the leaf shapes, and the geographical distributions as shown in the key.

Subspecies *glaber* is widely distributed in China; its extra-axillary inflorescences and firmly membranous elliptic-oblong leaves make it easy to separate from other related species. The staminal filaments are usually glabrous; however, a few specimens collected from Kwangsi and Yunnan are slightly papillose-tuberculate. Because of the intermediate leaf forms, staminal filaments, and distinctly geographical distributions, I consider the Chinese population as a subspecies of *C. stylosus.*

Under the provisions of the International Rules, priority of publication operates only within individual taxa. It would therefore be rather inappropriate to employ Loesener's epithet "puberula" in this instance, since Loesener chose the epithet with reference to the puberulence of the leaves of *Rosthorn 1556*[b], which actually is an abnormal condition for the other known specimens of *Celastrus stylosus* ssp. *glaber.* Thus, I have chosen the epithet "glaber" with reference to the more significant character of the staminal filaments.

23. Celastrus aculeatus Merr. in Lingn. Sci. Jour. 13:37. 1934. (T.: *Tsang 20092,* NY!).

Celastrus hookeri sensu Rehd. & Wils. in Sarg. Pl. Wils. 2:352. 1915, as to specimens cited, in part, non Prain.
Celastrus oblanceifolia Wang & Tsoong, in Chin. Jour. Bot. 1:65. 1936, ex char. (T.: *Tsoong 2443*).

Scandent shrubs up to 10 m. tall; branches terete, glabrous, the young branchlets sometimes brownish-pubescent, brownish-red to dark brown, both branches and branchlets lenticellate, the lenticels orbicular, sparse to dense. Axillary buds ovoid, about 2.5 mm. long, the outermost scales persistent, usually deltoid and spiny, acute to acuminate, accrescent, up to 5 mm. long. Leaves elliptic to oblanceolate, the apex acute, the base cuneate to obtuse, the margins remotely serrulate, 3–10 cm. long, 1.5–6.0 cm. wide, membranous, usually glabrous, rarely pubescent on the veins below, the primary lateral veins 4–5 pairs, arcuate toward the apex, immersed, distinct to slightly elevated below, obscure above, the veinlets usually obsolete on both surfaces; stipules laciniate, filiform, about 1 mm. long; petioles 7–12 mm. long. Inflorescences axillary and cauline at the lower part of the flowering branch, shortly pedunculate, the primary peduncles almost obsolete to 3 mm. long, usually 3-flowered, puberulous; flowers dioecious, greenish-yellow, subsessile, the articulation just below the flower. Male flowers: calyx lobes imbricate, ovate-deltoid to oblong, obtuse, entire, subglabrous without, accrescent, about 1.0–1.5 mm. long; petals oblong to oblanceolate, obtuse, slightly undulate, puberulent at the basal parts on both surfaces, about 3.5–4.5 mm. long and 1 mm. wide; disc fleshy, annular, entire; stamens arising from the margin of the disc proper, about 3 mm. long, the filaments filiform, densely papillose-tuberculate; sterile pistil ovoid, about 2 mm. long. Female flowers: calyx, petals, and disc as in the male; sterile stamens 1.5 mm. long, papillose; pistil subglobose, the style columnar, distinct, the stigmata discoid or slightly 3-lobed. Fruits subglobose, the valves broadly elliptic, about 8 mm. long and 7 mm. wide, 3- to 6-seeded; seeds

Fig. 13. *Celastrus aculeatus* Merr.

arcuate or semi-annular, about 4.5 mm. long and 1.5 mm. wide, brown, slightly wrinkled, distinctly areolate.

In open fields or in thickets, from lowland up to about 900 m. elevation; southeastern China; flowering from March to April.

CHINA: CHEKIANG: Sia-chu, *Ching 1664* (A, US); Taichow, *Ching 1336* (US); Tsishun, *Keng 285* (A); Tsingtien Hsien, *Keng 73* (A). FUKIEN: Amoy, *Chung 1514* (A, UC), *1693* (A, SING, US), *1773* (US), *4774* (A), *4777* (A), *5954*, *6235* (A); Baekliang and vicinity, *Siu-Ging Tang 15609* (UC); Chuanchow, *Chung 3085* (UC); Diongloh and vicinity, *Ku Tai Lin 11677* (UC); Foochow, *Norton 1346* (UC), *Chung-Chang Tang & Shan En Ma 2936* (US); Kuliang, *Chung 7264* (A, F); Kushan and vicinity, *Cheng 1573* (UC); Kutien, *Chung 4036* (A); Minhow Hsien, *Chung 2065* (UC); Pucheng, *Ching 2508* (A, UC, US); Tsze-chook-Hang, central Fukien, *Dunn s. n.* (HK, A); Yenping, *Kuang-Han Chou 8215*, *8460* (UC); Yuen-fu gorges, *Dunn s. n.* (HK, A). HUNAN: Yi-chang Hsien, *Tsang 23574* (A, US). KIANGSI: Kaoan, *Tsiang 10460* (NY); Kiennan Hsien, *Lau 4367* (A, S, US); Lungnan Hsien, *Lau 4801* (A, S, US); Lu Shan, *Chiao 18768* (US); Swe-chuen, *Hu 889* (A); Yung-shing, *Hu 784* (A); without precise locality, *Hu s. n.*, 1920 (UC). KWANGTUNG: Ho-yuen, *Tsang 28843* (A); Kowloon, *Wang 3060* (NY, SING); Mt. Lung-t'au, near Iu, *Kang-peng To et al 631* (US); Lungtung, *Tso 21640* (NY); Mei Hsien, *Tsang 21416* (A, NY, S); Mui-nen Hsien, *McClure & Shang 4* (UC); Naam-kwan-shan, Lung-men, *Tsang 25268* (A); Sin-fung Hsien, *Taam*

724, 1041 (A); Kakchieh, Swatow, *Gressitt 1767* (MO); Ta-ching, *Chun 5539* (A); Tapu, *Tsang 21189* (A, NY, S); Tsengshing Hsien, *Tsang 20092* (NY, holotype of *C. aculeatus;* A, isotype); Wai-yeung, *Tsui 154* (A, MO, NY, UC, US); Yao-shan, *Sin 11889* (NY).

This species is well characterized by the arcuate seeds, the papillose-tuberculate filaments, the fleshy and annular disc, and the obsolete veinlets of the leaves. *Celastrus aculeatus* is a very distinctive species of southeastern China. Most of the specimens which are cited here have been identified as *Celastrus hookeri* Prain. *Celastrus hookeri,* however, is easy to separate from *Celastrus aculeatus* by its glabrous filaments, its cup-shaped disc, and its ovoid seeds.

A specimen collected by Ching *(2508)* from northern Fukien has puberulent veins and slightly oblanceolate leaves. It matches the description of *Celastrus oblanceifolia* Wang & Tsoong from southern Anhwei which also has oblanceolate leaves. The veinlets described for *Celastrus oblanceifolia* are reported to be obsolete here and the seeds are said to be curved, both typical characters of *Celastrus aculeatus.* Because of these morphological similarities and the identical geographical distribution, *Celastrus oblanceifolia* is placed in synonymy.

24. Celastrus flagellaris Rupr. in Bull. Acad. Sci. St. Pétersb. II, 15:357. 1857, ex char.

Celastrus ciliidens Miq. in Ann. Mus. Bot. Lugd.-Bat. 2:85. 1865–66, ex char.
Celastrus clemacanthus Lévl., in Fedde, Rep. Spec. Nov. 8:284. 1910. (T.: *Taquet 632,* A!).

Scandent shrubs; branches and branchlets terete to slightly striate, glabrous, brown to dark brown, the lenticels small, oval, sparse, the young branchlets clinging by a line of filiform, branched aerial roots; axillary buds small, depressed-ovoid, usually protected by two prominent, broadly falcate, spiny scales, acuminate, about 3 mm. long. Leaves broadly elliptic to suborbicular, the apex obtuse to shortly acuminate, the base cuneate to obtuse, the margins finely ciliate-serrate, 3.0–5.5 cm. long, 2–5 cm. wide, delicately membranous, glabrous or puberulous on the veins below, the primary lateral veins 4–6 pairs, distinctly elevated below, slightly elevated above, the veinlets distinct, sometimes elevated below, obscure above; stipules laciniate, filiform, about 5 mm. long; petioles 1.5–2.5 cm. long. Inflorescences axillary, solitary or fascicled, or clustered on the short young branchlets, the peduncles about 2–5 mm. long; flowers dioecious, white or yellowish-green, the pedicels 1–4 mm. long, the location of articulation varying from the lower to upper half of the stalk. Male flowers: calyx lobes imbricate, oblong, obtuse, ciliate, about 2 mm. long; petals obovate-oblong to elliptic-oblong, ciliate to slightly erose, about 4 mm. long and 1.3 mm. wide; disc cup-shaped, the lobes inconspicuous; stamens arising from the margin of the disc, about 4 mm. long, the filaments fleshy, filiform, glabrous, the anthers ovoid, obtuse, apiculate, cordate; sterile pistil columnar, about 1 mm. long. Female flowers: calyx lobes, petals, and disc as in the male but smaller; sterile stamens about 0.5 mm. long, subsessile, triangular-cordate; pistil about 2.8 mm. long, the ovary subglobose, the style

columnar, distinct, the stigmata trilobed, each lobe deeply bifid, reflexed. Fruits globose, the valves broadly elliptic to suborbicular, 6–7 mm. long and 5–7 mm. wide, 3- to 6-seeded; seeds shortly ellipsoid, about 3.5 mm. long and 2 mm. wide, brown, the areolae obscure.

Lowland thickets, at altitudes up to 1,000 m.; China, Korea, and Japan; flowering from May to August.

CHINA: CHEKIANG: Yu-tsien, *Hu 1631* (A, UC). NORTHEASTERN CHINA: ad fl. Amur, *Maack s. n.*, 1855 (GH); sinus Possict, *Maximowicz s. n.*, 1860 (GH).

KOREA: Chulla, *Mrs. R. K. Smith s. n.* (A); Gyouhfeng, *Taquet 2723* (A); Quelpaert, scandens in muris agrorum Haouen, *Taquet 632* (A, type of *Celastrus clemacanthus*); Hongo-san, Prov. Hogen, *Wilson 10425* (A); Ping Yang, *Jack s. n.*, Sept. 18, 1908 (A); Puk Han, Seoul, *Jack s. n.*, Sept. 25, 1905 (A); Nam-san, Seoul (Heijyo), Prov. Heiki, *Wilson 8450* (A, US).

JAPAN: Kawagishi, Naganoken, *Uno 21823* (A, NY); Musatre, Mitake, *Hayakawa s. n.*, May 20, 1910 (S); Thinano, Suwa, *Sakurai s. n.*, May 21, 1913 (A); Thinano, Nagano, *Sakurai s. n.*, June 19, 1913 (A); near Lake Yamanaka, *Dorsett & Morse 619* (A, US).

This species is easily recognized by its characteristic ciliate-serrate leaves and the two persistent spiny outermost bud scales. Its branches sometimes produce aerial roots which function as attachment organs on smooth surfaces. The flowers are usually clustered on young shoots which occasionally elongate during the fruiting stage.

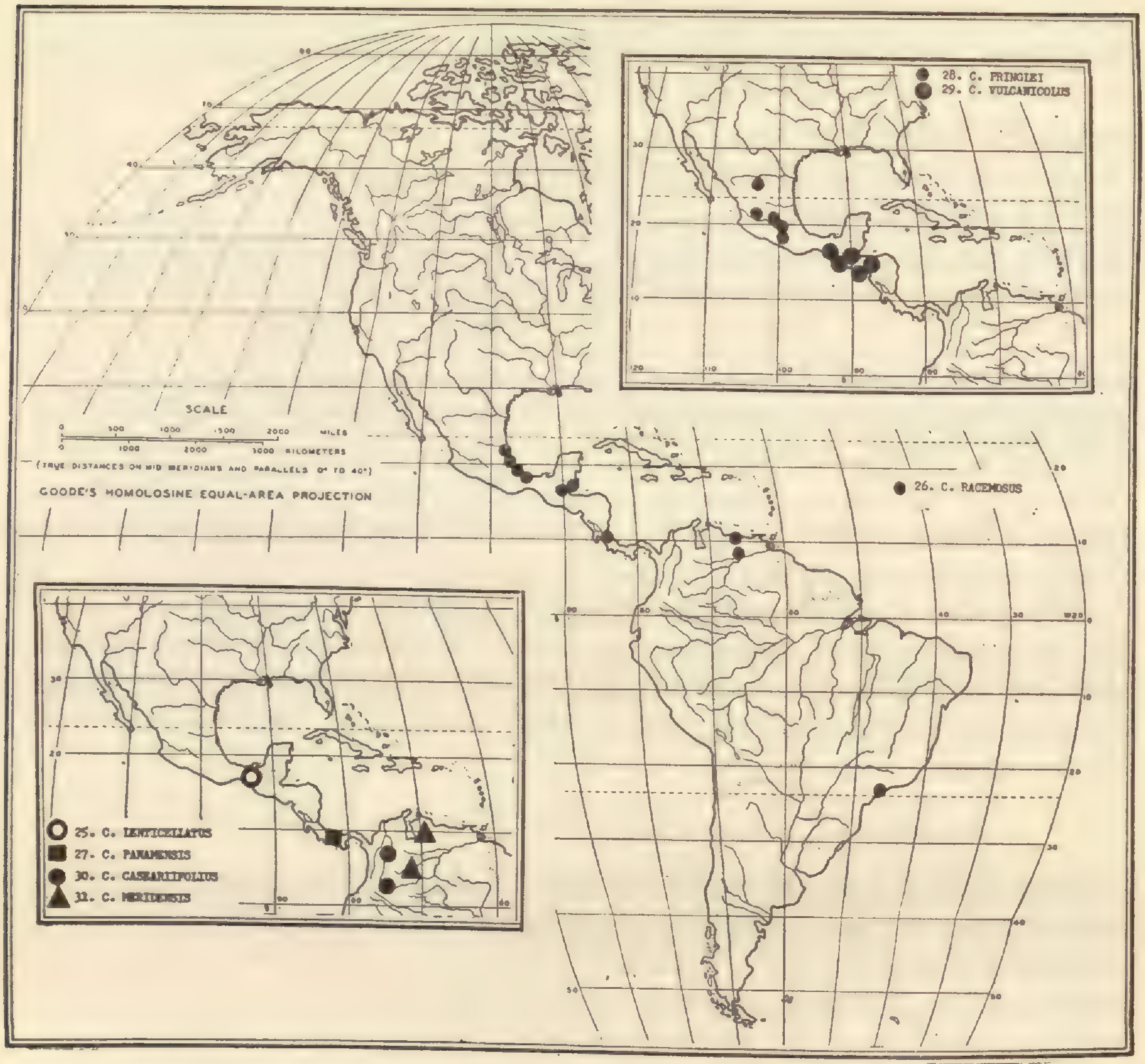
Subgenus II. RACEMOCELASTRUS Ding Hou, subgen. nov.

Frutices scandentes. Flores hermaphroditi; ovario triloculare, in quoque loculo ovulo singulo. Capsula semine singulo, ovulis manifeste abortivis binis. America centralis et australis.

Type species: *Celastrus racemosus* (Reiss.) Loes.

KEY TO THE SPECIES

A. Inflorescences paniculiform, obviously compound.
  B. Inflorescences thrice- or multi-compound, up to 14 cm. long; lenticels dense. Mexico: Chiapas .... 25. *C. lenticellatus*
  BB. Inflorescences usually once or twice compound, up to 6 cm. long; lenticels scattered.
    C. Inflorescences usually clustered in the leaf axils; peduncles not associated with vegetative buds; leaves elliptic. Brazil, Venezuela, Costa Rica, British Honduras, Guatemala, El Salvador, and Veracruz, Mexico........ 26. *C. racemosus*
    CC. Inflorescences solitary in the leaf axils; peduncles associated with vegetative buds; leaves ovate. Panama .... 27. *C. panamensis*
AA. Inflorescences racemiform, obscurely compound.
  D. Pedicels of the flowers 1–2 mm. long.
    E. Anthers distinctly apiculate; fruit valves about 12–14 mm. long, the septa 1.0–2.5 mm. wide; leaves closely serrate. Central Mexico........ 28. *C. pringlei*
    EE. Anthers obscurely apiculate; fruit valves about 14–18 mm. long, the septa 4.0–6.0 mm. wide; leaves remotely serrate to entire. Chiapas, Mexico; Guatemala; Honduras; El Salvador .... 29. *C. vulcanicolus*
  DD. Pedicels of the flowers obsolete or less than 1 mm. long.
    F. Leaves oblanceolate-oblong; lenticels large, dense and elevated; anthers apiculate. Colombia .... 30. *C. caseariifolius*
    FF. Leaves broadly elliptic or ovate; lenticels small, sparse and obscure; anthers not apiculate. Colombia and Venezuela .... 31. *C. meridensis*



Map 4. Distribution of seven species of *Celastrus* Subgenus RACEMOCELASTRUS.

25. CELASTRUS LENTICELLATUS Lundell, in Bull. Torr. Bot. Club 67:616. 1940. (T.: *Purpus 7370*, US!).

Scandent shrubs; branches glabrous, black-brown, the lenticels small, dense, white, slightly elevated; axillary buds conoid, acute, about 2 mm. long. Leaves broadly elliptic, the apex abruptly short-acuminate, the base cuneate to rotund, the margins remotely serrulate, 10–20 cm. long, 5.0–7.8 cm. wide, chartaceous, glabrous, the primary lateral veins distinctly elevated below, plane or slightly impressed above, the veinlets prominent below, obscure to visible above. Stipules filiform, about 1 mm. long; petioles rather stout, 6–12 mm. long. Inflorescences axillary as well as terminal, solitary or fasciculate, thrice or multicompound, paniculiform, up to 14 cm. long, much branched at the base, the peduncles glabrous, the primary peduncles 1–5 mm. long; flowers bisexual, the pedicels about 1 mm. long, the articulation at the lower part of the stalk. Calyx lobes valvate, ovate, rotund, minutely erose, 0.5–0.8 mm. long; petals oblong, rotund, entire, brown-punctate, 1.8 mm. long and 1 mm. wide; disc fleshy, flat, about 1.5 mm. in

diameter, the lobes depressed-rectangular; stamens attached slightly under the margin of the disc, about 2 mm. long, the filaments filiform, glabrous, the anthers ovoid, obtuse, slightly apiculate; pistil short, ovoid, about 1 mm. long, the style stout, the stigmata obscure. Fruit unknown.

Mexico: Chiapas; flowering in June.

MEXICO: Chiapas, Finca San Cristobal, *Purpus 7370* (F, type; MICH; US, holotype).

The paniculiform inflorescences and the densely lenticellate branches make this species easily separated from other Latin American *Celastrus* species.

26. CELASTRUS RACEMOSUS (Reiss.) Loes. in Engl. Bot. Jahrb. 24:199. 1898, (as *racemosa*).

Maytenus racemosus Reiss. in Mart. Fl. Bras. 11:30, *pl. 4, f. 15.* 1861. (T.: *Riedel s. n.*, US!).
Celastrus liebmannii Standl. in Publ. Field Mus. Bot. 8:316. 1931. (T.: *Liebmann 14871*, MO!).
Celastrus pachyrachis Lundell, in Lilloa 4:382. 1939. (T.: *Jahn 476*, US!).
Celastrus mainsiana Lundell, in Lloydia 2:99. 1939. (T.: *Lundell 6307*, MICH!).

Scandent shrubs up to 50 m. tall; branches terete, glabrous, blackish-brown, the lenticels scattered to dense, white, elliptic to orbicular; axillary buds conoid, acute, about 1 mm. long. Leaves elliptic to ovate, the apex acute, the base cuneate to rotund, the margins crenulate-serrulate, 5–12 cm. long, 3–5 cm. wide, firmly membranous, glabrous, the primary lateral veins 7–9 pairs, slightly elevated below, plane and visible above; stipules subulate, erose, about 1 mm. long; petioles 3–10 mm. long. Inflorescences axillary, 1- to 3-branched, once compound, up to 4 cm. long, the primary peduncle glabrous, about 3 mm. long; flowers bisexual, greenish-white, the pedicels 2–3 mm. long, accrescent, the articulation toward the base of the stalk. Calyx lobes imbricate, deltoid, obtuse, subentire, brownish-punctate, about 1 mm. long; petals oblong, obtuse, subentire, about 1.5 mm. long and 1 mm. wide; disc fleshy, flat, about 1.5 mm. in diameter, the lobes subreniform; stamens attached slightly beneath the disc margin, about 1.5 mm. long, the filaments linear, glabrous, the anthers ovoid, obtuse, rarely apiculate; pistil ovoid, about 1 mm. long, the style columnar and blunt. Fruits ellipsoid, the pedicels 2.5–5.0 mm. long, the valves broadly elliptic, 14–21 mm. long and 8–11 mm. wide, the septa 2.5–6.0 mm. wide, 1-seeded; seeds cylindric, about 10–13 mm. long and 7–9 mm. wide, pinkish-brown, areolae obscure.

In wet forests or thickets, at altitudes 1,400–2,400 m.; Mexico, British Honduras, Guatemala, Costa Rica, Venezuela, and Brazil; flowering from March to August.

BRAZIL: Rio de Janeiro, *Riedel s. n.* (US, type of *Maytenus racemosus*).
BRITISH HONDURAS: El Cayo Dist., *Lundell 6307* (MICH, holotype of *C. mainsiana*).
COSTA RICA: Heredia, *Standley & Valerio 52024* (US).
GUATEMALA: Tactic, *Standley 71349* (F).
MEXICO: VERA CRUZ: near Jalapa, *Pringle 8133* (K, MO, NY, S, UC, US); Mirador, *Liebmann 14871* (F, type of *C. liebmannii*; MO), *14872, 14873, 14874, 14875*[a], *14875*[b] (F), *14875* (GH, UC, US), *Purpus 8926* (MO, NY, UC, US); Zacuapan, *Purpus 7094* (F, MO, NY, UC), *8080* (MO, NY, UC, US).

Venezuela: east of El Junquito, *Steyermark 57015* (F, NY, US); Macarao, *Jahn 476* (US, holotype of *C. pachyrachis*).

This is a widely and disjunctively distributed species of the Latin American *Celastrus*. It is found in the rain forests or thickets from Vera Cruz, Mexico, southward to Rio de Janeiro, Brazil.

Lundell[41] has stated, "from examination of the type photograph of *C. racemosus* (Reiss.) Loes., the similarity of that species and the type of *C. liebmannii* is striking." I have seen the types of *Celastrus racemosus* and *C. liebmannii;* in addition, I have examined specimens collected from Vera Cruz, British Honduras, Guatemala, Costa Rica, and Venezuela. They are all similar and excessively difficult to separate into two species.

This species is closely related to *Celastrus pringlei* Rose and *C. vulcanicolus* Donn. It can be distinguished from them by the distinctly once compound, aggregate dichasia and longer pedicels. The other two species bear racemiform inflorescences and have very short pedicels.

27. Celastrus panamensis Lundell, in Contr. Univ. Mich. Herb. 6:40. 1941. (T.: *Allen 319*, MO!).

Scandent shrubs; branches terete, glabrous, smooth, shining, reddish-brown, the lenticels small, obscure, elliptic; axillary buds conoid, acute, about 1 mm. long. Leaves ovate, the apex obtuse, the base rotund, the margins shallowly crenate, 9–14 cm. long, 5.0–7.5 cm. wide, membranous, glabrous, the primary lateral veins 7–8 pairs, elevated below, plane and distinct above, the veinlets slightly elevated below, plane and visible above; stipules deltoid, erose, about 1 mm. long; petioles 11–13 mm. long. Inflorescences axillary as well as terminal, up to 6 cm. long, usually twice compound, the primary peduncles glabrous, about 1.2–2.5 cm. long, associated with a vegetative bud in the axil; flowers bisexual, white, the pedicels about 1 mm. long, the articulation toward the base of the stalk. Calyx lobes imbricate, obtuse, minutely erose, about 1.2 mm. long, brownish-punctate; petals oblong, rotund, more or less entire, about 2 mm. long and 1.2 mm. wide; disc fleshy, flat, about 2 mm. in diameter, the lobes subreniform; stamens attached slightly beneath the margin of the disc, about 2 mm. long, the filaments filiform, glabrous, the anthers ovoid, slightly apiculate; pistil short, conoid, about 1.5 mm. long, the style columnar and blunt. Fruit unknown.

At altitudes 1,400–2,300 m.; Panama; flowering in April.

Panama: chiriqui: *Allen 319* (MO, type; P).

The floriferous branch of this species is very characteristic and different from other Latin American *Celastrus* species in having the peduncle with an associated axillary vegetative bud. I have seen only the type collection. It is a young flowering branch.

---

[41] In Lilloa 4:380. 1939.

Fig. 14. *Celastrus Pringlei* Rose

28. CELASTRUS PRINGLEI Rose, in Contr. U. S. Nat. Herb. 5:195. 1899. (T.: *Pringle 6842*, MO!).

Celastrus longipes Lundell, in Lilloa 4:381. 1939. (T.: *Palmer 106*, MO!).

Scandent shrubs up to 5 m. high; branches terete, glabrous, brown or reddish-brown, densely lenticelled, the lenticels elliptic or ovate, slightly elevated, white; axillary buds suborbicular, about 1 mm. long. Leaves narrowly elliptic, the apex acute to acuminate, the base attenuate, the margins serrulate, 6–10 cm. long, 2–4 cm. wide, membranous, glabrous, the primary lateral veins 7 pairs, elevated below, plane and distinct above, the veinlets slightly elevated beneath, visible above; stipules filiform, tufted, about 1 mm. long; petioles 5–12 mm. long. Inflorescences axillary, 1- to 4-branched, racemiform, usually 2.0–3.5 cm. long, the primary peduncles glabrous, obscure to about 5 mm. long, the secondary peduncles about 3–8 mm. long, with 2–3 prophylls; flowers bisexual, white, the pedicels about 1.2 mm. long, the articulation usually at the upper half of the stalk. Calyx lobes imbricate, ovate, marginate, scarious and slightly ciliate, about 1.5 mm. long; petals obovate, rotund, slightly erose, 2.5 mm. long and 1.2 mm. wide; disc fleshy, flat, the lobes depressed-subquadrate; stamens attached just beneath the disc margin, about 2.5 mm. long, the filaments linear, glabrous, the anthers suborbicular, apiculate; pistil flask-shaped, about 2 mm. long, the ovary ovoid, the style cylindric and blunt. Fruits ovoid, the valves 12–14 mm. long and 7.5–9.5 mm. wide, the

septa 1.0–2.5 mm. wide, 1-seeded; seeds broadly ellipsoid, 10–12 mm. long and 7 mm. wide, pinkish-brown, shining, the areolae distinct.

In forests, at altitudes 790–2,300 m.; Mexico; flowering from March to June.

MEXICO: canyons of mountains above Cuernavaca, *Pringle 6842* (MO, type of *C. pringlei;* GH, L, S, UC); Temascaltepec, *Hinton 290* (F), *3506* (GH, US), *3574* (NY, US), *3717*, *6076*, *7203* (GH, US), *7380* (US), *9020* (GH, US). DURANGO: San Ramón, *Palmer 106* (MO, type of *C. longipes;* US). JALISCO: *McVaugh 10246*, *10308*, *13906* (MICH). MICHOACAN: Tancitaro, *Leavenworth & Hoogstraal 1023* (F, GH, MICH, MO, NY). MORELOS: Sierra de Tepoxtlan, *Pringle 6998* (GH, MICH, MO, NY, S, UC).

The type specimen of *Celastrus longipes* seems to have larger leaves and longer peduncles than the type of *C. pringlei.* These characters are variable in all the specimens I have examined, and I think that they might be due to the differences in altitude. I have found some floriferous branches which are subtended by foliage leaves. This subtending foliage leaf may be from the previous year's growth. For example, a specimen *(McVaugh 10308)*, collected at altitudes 2,400–2,600 m. in Jalisco, Mexico, on April 14, has a main branch bearing three floriferous branches. Each of the branches is subtended by a foliage leaf. When I made a cross-section of the main branch two porous rings of spring wood showed clearly. From this I assumed it might be an evergreen species, but, Dr. McVaugh told me he has collected another specimen in fruit with all of the leaves fallen off.

29. CELASTRUS VULCANICOLUS Donn. Smith, in Bot. Gaz. 61:373. 1916. (T.: *Donn. Smith 2549*, US!).

Celastrus chiapensis Lundell, in Lilloa 4:380. 1939. (T.: *Matuda 2080*, MICH!).
Celastrus siltepecanus Lundell, in Wrightia 1:155. 1946. (T.: *Matuda 5192*, MO!).
Maytenus williamsii A. Molina R., in Ceiba 1:258. 1951. (T.: *Merrill et al 15640*, F!).

Scandent shrubs up to 7 m. tall; branches terete, glabrous, gray to reddish-brown, the lenticels obscure on the gray branches while distinct on the reddish-brown ones, orbicular or ovate; axillary buds globose, about 1 mm. in diameter. Leaves elliptic, the apex acuminate or acute, the base cuneate or obtuse, the margins entire, repand, or slightly serrulate, 6–12 cm. long, 2.5–5.0 cm. wide, firmly membranous, glabrous, the primary lateral veins 7–9 pairs, curved toward the apex, elevated below, plane and distinct above, the veinlets slightly elevated below, obscure to visible above; stipules filiform, about 1 mm. long; petioles 4–12 mm. long. Inflorescences axillary, racemiform, 1- to 5-branched, up to 3.5 cm. long, few-flowered, the primary peduncles glabrous, obsolete to about 5 mm. long, the secondary peduncles about 3 mm. long, usually with 2 prophylls; flowers bisexual, pale green, the pedicels about 2 mm. long, the articulation usually at the middle or lower half of the stalk. Calyx lobes ovate or deltoid, thick, obtuse, marginate, scarious, slightly erose, about 1 mm. long; petals oblong-elliptic, obtuse, minutely erose, about 2.0–2.5 mm. long and 1 mm. wide; disc fleshy, flat, about 2 mm. in diameter, the lobes depressed-rectangular; stamens attached beneath the disc margin, about 2 mm. long, the filaments filiform, glabrous, the anthers subglobose, slightly apiculate; pistil 1.5 mm. long, the style slender and blunt. Fruits ellipsoid, the valves broadly elliptic, about 14–18 mm. long and 7–10 mm. wide, 1-seeded;

seeds ellipsoid, 12–14 mm. long and 6–9 mm. wide, reddish-brown, shining, the areolae obscure.

In forests, at altitudes 1,300–2,400 m.; Mexico, Guatemala, Honduras, and El Salvador; flowering from December to January.

El Salvador: Santa Ana, north of Metapán, *Carlson 900* (F).

Honduras: Dept. Morazan, *Merrill et al. 15640* (F, type of *Maytenus williamsii;* US); San Juancito, *Williams & Molina R. 17100* (F).

Guatemala: Dept. Alta Verapaz, *Standley 71349* (F); Dept. Chiquimula, *Steyermark 31480* (F); Dept. Quezaltenango, *Steyermark 33635, 33692, 33775* (F), *Standley 65402* (F), *65411, 86972* (F, MICH); Dept. Sacatepequez, *Standley 63667* (F), *Donn. Smith 2549* (US, type of *C. vulcanicolus*).

Mexico: chiapas: Fraylesca, Siltepec, *Matuda 5192* (MO, type of *C. siltepecanus*); Cascada, Siltepec, *Matuda 5148* (F); Mt. Ovando, *Matuda 2080* (MICH, holotype of *C. chiapensis*), *3944* (F, MICH, MO, NY, US), *16396* (UC). hidalgo: Molango, *Moore 2698* (GH). oaxaca: Cumbre de Talea, *Reko 4019* (US).

This species is closely related to *Celastrus pringlei* Rose, but can be distinguished from it by the entire or remotely serrulate leaf margins, the obscure connectives, the larger fruits with wider septa, and especially the geographical distribution.

The type specimens of *Celastrus siltepecanus* Lundell is similar to the present species except for the distinct and slightly elevated veins on both surfaces of the leaves, and the small distinct lenticels borne on the branches. These characters might be caused by the environment and are within the range of variation of the species.

The specimens assigned to *Maytenus williamsii* A. Molina R. are *Celastrus* and are congruent with the present species. The leaves and fruits are smaller, which might be due to the high altitude of the habitat.

30. Celastrus caseariifolius Lundell, in Lilloa 4:379. 1939. (T.: *Lehmann s. n.*, F!).

Branchlets terete, glabrous, reddish-brown, densely lenticellate, the lenticels oval, elevated; axillary buds conoid, about 1.5 mm. long. Leaves oblanceolate-oblong or elliptic-oblong, the apex acute to shortly acuminate, the base obtuse, the margins remotely serrulate, 4.5–10.5 cm. long, 1.4–4.0 cm. wide, chartaceous, glabrous, the primary lateral veins 7–9 pairs, veins and veinlets slightly elevated below, obscure above; petioles 3–5 mm. long. Inflorescences axillary, racemiform, 1- or 2-branched, up to 2.5 cm. long, the primary peduncles obscure, the secondary peduncles about 1.5 mm. long. Flowers (young) bisexual, the pedicels obsolete to about 0.8 mm. long, the articulation at the upper half of the stalk. Calyx lobes imbricate, ovate or ovate-deltoid, erose-ciliolate; petals ovate-oblong, obtuse, subentire; disc fleshy, flat, the lobes obscure, the stamens arising from the margin of the disc, the filaments glabrous, the anthers suborbicular, apiculate; pistil ovoid, the style short and columnar, the stigmata obscure. Fruits cylindric, the valves oblong, about 16 mm. long and 7 mm. wide, 1-seeded; seeds cylindric, obtuse at both ends, 15 mm. long and 6 mm. wide, black and smooth.

In the forests of highlands, at altitudes 1,600–2,000 m.; Colombia; flowering from May to June.

Colombia: Dept. de Antioquia, *Daniel 3295* (F); highlands of Popayan, *Lehmann s. n.*, 1,600–2,000 m. elev., May 1889 (F, holotype), *399* (L, NY).

Celastrus caseariifolius is characterized by the innumerable, elevated and crowded lenticels, very much resembling a crowded colony of plant lice (aphids). Further, its chartaceous and oblanceolate-oblong leaves are distinctive.

31. Celastrus meridensis Pittier, in Bol. Soc. Venez. Cienc. Nat. 3:423. 1927. (T.: *Gehringer 298*, US!).

Maytenus meridensis (Pittier) Cuatr. in Fieldiana, Bot. 27^2:82. 1951.

Scandent shrubs; branches slightly striate, glabrous, brownish, the lenticels sparse, elliptic, slightly elevated, white, obscure on the young branchlets; axillary buds ovoid, about 2 mm. long. Leaves ovate, ovate-oblong, or obovate, the apex rotund to abruptly acute, the base cuneate to rotund, the margins remotely crenate-serrate, 4.5–7.0 cm. long, 2–5 cm. wide, firmly chartaceous, glabrous, the primary lateral veins 5–7 pairs, elevated below, plane and distinct above, the veinlets visible below, obscure above; stipules filiform, about 1 mm. long; petioles 3–7 mm. long. Inflorescences axillary, simple, racemiform, up to 5 cm. long, the primary peduncles obscure, glabrous, the secondary peduncles about 1 mm. long, with 2 small prophylls; flowers bisexual, white, the pedicels obscure, accrescent, up to 3 mm. long on the fruiting specimens. Calyx lobes imbricate, ovate, rotund, slightly erose, thick, about 1.2 mm. long; petals oblong, obtuse, slightly erose, about 2.6 mm. long and 1.3 mm. wide; disc fleshy, flat, about 1.6 mm. in diameter, the lobes depressed, subreniform; stamens attached just beneath the disc margin, about 2 mm. long, the filaments linear, glabrous, the anthers ovoid, obtuse; pistil pear-shaped, about 1.5 mm. long, the style short, columnar and blunt. Fruits ovoid, the valves broadly ovate to suborbicular, about 11 mm. long and 7.5–9.0 mm. wide, the septa 2–3 mm. wide, 1-seeded; seeds ellipsoid, 7 mm. long and 5 mm. wide, reddish-brown, shining, the areolae obscure.

In thickets, at altitudes 2,490–2,700 m.; Colombia and Venezuela; flowering in July.

Colombia: Cordillera Oriental, Dept. Boyacá, *Cuatrecasas 1813, 1831* (F, US).
Venezuela: Mucurubá, *Gehriger 298* (US, type; F, NY).

This species distinctly belongs to *Celastrus*. The morphological characters match the generic characters very well. The type specimen is a scandent, flowering plant. In addition to the type, I have several fruiting specimens at hand, which confirm this view.

Cuatrecasas[42] transferred this species to *Maytenus* based on his own collections (*1813* and *1831*, F, US). He says, "My specimens were obtained from trees, justifying their inclusion in the genus *Maytenus*". On examining the specimens, especially *Cuatrecasas 1813* US, one can see easily the twisted branches; it seems a scandent plant. Unfortunately, there is no habit data on the specimens. Since all the *Celastrus* species are scandent shrubs, I assume that Dr. Cuatrecasas' specimens "obtained from trees" were in reality scandent.

[42] In Fieldiana, Bot. 27^2:82. 1951.

Doubtful Species

The type specimens or representative specimens of the following species are not available, while their original descriptions alone are not sufficient to place them.

Celastrus discolor Lévl. in Bull. Géogr. Bot. 24:142. 1914 (T.: *Cavalerie 3919*). China.

Celastrus grenadensis Urb. Symb. Antill. 5:51. 1904 (T.: *Eggers 6222*). Ind. Occ.

Celastrus microcarpus D. Don, Prod. Fl. Nep. 191. 1825 (T.: *Kamroop s. n.*). Reg. Himal.

Celastrus racemosus var. trinitensis Urb. Symb. Antill. 5:52. 1904 (T.: *Baptiste 5857*). Trinidad.

Celastrus repandus Bl. Bijdr. Fl. Ned. Ind. 1145. 1825 (T.: none). Java.

Celastrus reticulatus Wang in Chin. Jour. Bot. 2:68. 1937 (T.: *Leu 233*). China.

Excluded Species

From this list have been omitted all indigenous species of Africa proper, most of which are species of *Gymnosporia* or *Maytenus* and require special study of precise disposition.

Celastrus acuminatus Wall. Cat. no. 4342. 1831 = Chailletia gelonioides Hook. f. Fl. Brit. Ind. 1:570. 1875.

Celastrus adenophylla Miq. Ann. Mus. Bot. Lugd. Bat. 2:85. 1865=Ilex crenata Thunb. Fl. Jap. 78. 1784.

Celastrus alatus Thunb. Fl. Jap. 98. 1784 = Euonymus thunbergianus Bl. Bijdr. Fl. Ned. Ind. 1147. 1825.

Celastrus alpestris Bl. Bijdr. Fl. Ned. Ind. 1145. 1825 = Perrottetia alpestris Loes. in Engl. & Prantl, Nat. Pflanzenfam. III, 5:220. 1892.

Celastrus aphyllus Schlecht. in Linnaea 15:458. 1841 = Acanthothamnus aphyllus Standl. in Contr. U. S. Nat. Herb. 23:684. 1923.

Celastrus aquifolius Regel, Ind. Sem. Hort. Pétrop. 36. 1856, nom. nud.

Celastrus attenuatus Wall. Cat. no. 4319. 1831 = Gymnosporia neglecta Lawson in Hook. Fl. Brit. Ind. 1:619. 1875.

Celastrus bilocularis F. Muell. in Trans. Phil. Inst. Vict. 3:31. 1859 = Maytenus bilocularis (F. Muell.) Loes. in Engl. & Prantl, Nat. Pflanzenfam. 2 Abt. 20b:135. 1942.

Celastrus bivalvis Jack, in Malay. Misc. 1:19. 1820 = Microtropis bivalvis Wall. Cat. no. 4340. 1831.

Celastrus boaria Baill. Hist. Pl. 6:26. 1877, in text, nom. nud. = Maytenus boaria Molina, Saggio Stor. Nat. Chile, ed. 1, 177. 1778.

Celastrus bodinieri Lévl. in Fedde, Rep. Sp. Nov. 13:263. 1914 = Ilex purpurea Hassk. Cat. Pl. Bogor. 230. 1844; Rehd. in Jour. Arnold Arb. 14:239. 1933.

Celastrus buxifolia Wall. in Roxb. Hort. Beng. 18. 1814, nom. nud.; Fl. Ind. ed.

Carey & Wall. 2:396. 1824, in syn.: *Celastrus rigidus* Wall. = Gymnosporia wallichiana Laws. in Hook. Fl. Brit. Ind. 1:621. 1875.

Celastrus cavaleriei Lévl. in Fedde, Rep. Sp. Nov. 13:262. 1914 = Myrsine semiserrata Wall. in Roxb. Fl. Ind. ed. Carey & Wall. 2:293. 1824; Rehd. in Jour. Arnold Arb. 15:292. 1934.

Celastrus chungii Merr. in Sunyatsenia 3:253. 1937 = Tripterygium Wilfordii Hook. in Benth. & Hook. Gen. Pl. 1:368. 1862–67.

Celastrus circumcissus Pavon, mss.; Briq. in Ann. Conserv. & Jard. Bot. Genève 20:253. 1919 = Maytenus orbicularis (Willd.) Loes. in Engl. Bot. Jahrb. 50 (Beibl. 111):10. 1913.

Celastrus colombianus Cuatrec. in Fieldiana Bot. 27^2:81. 1951 = Ilex scandens Cuatrec. in Lloydia 11:207. 1949.

Celastrus confertus Ruiz & Pavon, Fl. Peruv. 3:7. 1802 = Maytenus confertus (Ruiz & Pavon) Loes. in Engl. & Prantl, Nat. Pflanzenfam. 2 Abt. 20b:146. 1942.

Celastrus crenatus Forst. f. Prod. 19. 1786 = Gymnosporia crenata (Forst.) Seem. Fl. Vit. 1:40. 1865.

Celastrus crenatus sensu F. Brown in Bull. Bishop Mus. Honolulu no. 130:158. 1935, non Forst. = Gymnosporia sp., ex char.

Celastrus crenatus sensu Hook. & Arn. Bot. Beechey Voy. 61. 1841 = Gymnosporia vitiensis (A. Gray) Seem. Fl. Vit. 1:41. 1865.

Celastrus crenatus Roth, Nov. Pl. Sp. 156. 1821 = Gymnosporia montana Benth. Fl. Austral. 1:400. 1863.

Celastrus crenulatus Wall. Cat. no. 4323. 1831, nom. nud.

Celastrus cuneifolius (Wr. ex A. Gray) Gomez de la Maza in Ann. Inst. Segunda Enseñanza 2:172. 1895 = Euonymus cuneifolius C. Wright ex A. Gray in Mem. Am. Acad. n. s. 8:171. 1861—not *Celastrus* (capsules 2-valved).

Celastrus cunninghamii F. Muell. in Trans. Phil. Inst. Vict. 3:30. 1859 = Maytenus cunninghamii (F. Muell.) Loes. in Engl. & Prantl, Nat. Pflanzenfam. 2 Abt. 20b:136. 1942.

Celastrus cunninghamii var. *parviflora* F. M. Bailey in Queensland Agr. Jour. 29:178, *pl. 22.* 1912 = Maytenus cunninghamii (F. Muell.) Loes. in Engl. & Prantl, loc. cit. 1942.

Celastrus dilatatus Thunb. in Trans. Linn. Soc. 2:332. 1794 = Orixa japonica Thunb. Nov. Gen. Pl. 3:57. 1783.

Celastrus disperma F. Muell. in Trans. Phil. Inst. Vict. 3:31. 1859 = Maytenus dispermus (F. Muell.) Loes. in Engl. & Prantl, Nat. Pflanzenfam. Abt. 2. 20b:135. 1942.

Celastrus diversifolia Hemsl. in Jour. Linn. Soc. 23:123. 1886 = Gymnosporia diversifolia Maxim. in Bull. Acad. Sci. St. Pétersb. III, 27:459. 1881.

Celastrus dubia Spreng. Syst. Veg. 1:774. 1825—not *Celastrus* (capsules 2-valved).

Celastrus emarginatus Ruiz & Pavon, Fl. Peruv. 3:6, *t. 229, f. a.* 1802 = Maytenus retusa Briq. in Ann. Conserv. & Jard. Bot. Genève 20:351. 1919.

Celastrus emarginatus Willd. Sp. Pl. 1^2:1128. 1798 = Gymnosporia emarginata Thw. Enum. Pl. Zeyl. 409. 1864.

Celastrus esquirolianus Lévl. Fl. Kouy-Tchêou, 69. 1914 = Rhamnus crenatus Sieb. & Zucc. in Abh. Bayer. Akad. Muench. II, 4:146. (Fl. Jap. Fam. Nat. 1:38). 1845; Rehd. in Jour. Arnold Arb. 15:13. 1934.

Celastrus esquirolii Lévl. in Fedde, Rep. Sp. Nov. 13:262. 1914 = SABIA PARVIFLORA Wall. var. NITIDISSIMA Lévl. Fl. Kouy-Tchéou, 379. 1915; Rehd. in Jour. Arnold Arb. 15:10. 1934.

Celastrus euonymoidea Lévl. Fl. Kouy-Tchéou, 419. 1915 = GREWIA FEDDEI (Lévl.) Burret in Notizbl. Bot. Gart. Berlin 9:678. 1926.

Celastrus fasciculatus Drake in Grandidier, Hist. Phys., Nat., e Pol. de Madag. 35 (Hist. Nat. Pl. Atlas 3:*pl. 280*). 1896 = GYMNOSPORIA sp., ex ill.

Celastrus feddei Lévl. in Fedde, Rep. Sp. Nov. 13:263. 1914, quoad specim. *Esquirol 3189* = GREWIA HENRYI Burret in Notizbl. Bot. Gart. Berlin 9:674. 1926; Rehd. in Jour. Arnold Arb. 18:221. 1937.

Celastrus feddei Lévl. in Fedde, Rep. Sp. Nov. 13:263. 1914, excl. *Esquirol 3189* = GREWIA FEDDEI (Lévl.) Burret, loc. cit. 678. 1926.

Celastrus finlaysonianus Wall. Cat. no. 4324. 1831, nom. nud.

Celastrus floribundus Span. in Linnaea 15:186. 1841, nom. nud.

Celastrus fournieri Panch & Sebert, Not. Bois Nouv. Caléd. 234. 1874 = MAYTENUS FOURNIERI (Panch. & Sebert) Loes. in Engl. & Prantl Nat. Pflanzenfam. 2, Abt. 20b:138. 1942.

Celastrus glaucus Vahl, Symb. Bot. 2:42. 1791 = ELAEODENDRON GLAUCUM Pers. Syn. Pl. 1:241. 1805.

Celastrus haenkea Spreng. Syst. Veg. 4^2:88. 1827 = SCHOEPFIA FLEXUOSA Roem. & Schult. Syst. Veg. 5:160. 1819.

Celastrus hamelii Spreng. Syst. Veg. 1:774. 1825 = RHAMNUS RACEMOSUS Duham. Traité Arb. et Arbust. ed. nov. 3:48. 1806.

Celastrus heterophyllus Savi in Mem. Accad. Sci. Torino 38:163 (Mem. de C. G. Savi, p. 11, *tab.* II, *f. 2.*). 1835—not *Celastrus* (fruit triangular).

Celastrus heyneana Roth in Roem. & Schult. Syst. Veg. 5:421. 1819, p. p. = GYMNOSPORIA HEYNEANA Laws. in Hook. Fl. Brit. 1:620. 1875.

Celastrus ilicifolius Schrad. in Goett. Gel. Anz. 1:716. 1821 = MAYTENUS TRUNCATUS Reiss. in Mart. Fl. Bras. 11^1:5. 1861.

Celastrus japonicus (Thunb.) Koch, Dendrol. 1:625. 1869 = ORIXA JAPONICA Thunb. Nov. Gen. Pl. 3:57. 1783.

Celastrus jodinii Steud. ex Göpp. in Gartenflora 3:312. 1854, in obs.: *Ilex cuneifolia* Hook. f. = TRICHILIA JODINII (Steud. ex Göpp.) Briq. in Candollea 6:21. 1935.

Celastrus kouytchensis Lévl. in Fedde, Rep. Sp. Nov. 13:264. 1914 = RHAMNUS CRENATUS Sieb. & Zucc. in Abh. Bayer. Akad. Müench. II, 4:146. (Fl. Jap. Fam. Nat. 1:38.) 1845.

Celastrus leptopus Drake in Grandidier, Hist. Madag. 35. (Hist. Nat. Pl. Atlas 3, *pl. 280*^{A}). 1896 = GYMNOSPORIA sp., ex ill.

Celastrus linearis var. *madagascariensis* Drake in Grandidier, loc. cit., *pl. 280*^{B}. 1896 = GYMNOSPORIA sp., ex ill.

Celastrus lineatus (Wr.) Gomez de la Maza in Ann. Soc. Españ. Hist. Nat. 19:239. 1890 = MAYTENUS LINEATUS C. Wr. in Griseb. Cat. Pl. Cub. 54. 1866.

Celastrus listeri Prain in Jour. Asiat. Soc. Beng. 73:197. 1904 = Gymnosporia sp.

Celastrus lucida Wall. in Roxb. Fl. Ind. ed. Carey & Wall. 2:400. 1824—not *Celastrus* (ovary many-celled).

Celastrus lycioides Bross. ex Willd. in Roem. & Schult. Syst. Veg. 5:427. 1819—not *Celastrus* (branches spiny).

Celastrus lyi Lévl. in Fedde, Rep. Sp. Nov. 13:264. 1914 = Rhamnus esquirolii Lévl. in Fedde, Rep. Sp. Nov. 10:473. 1912.

Celastrus macrocarpus Ruiz & Pavon, Fl. Peruv. 3:8, *t. 230, f. b.* 1802 = Maytenus macrocarpus (Ruiz & Pav.) Briq. in Ann. Conserv. & Jard. Bot. Genève 20:361. 1919.

Celastrus ? magellanicus DC. Prod. 2:8. 1825 = Maytenus magellanicanus Hook. f. Fl. Antarct. 254. 1847.

Celastrus mairei Lévl. in Fedde, Rep. Spec. Nov. 13:264. 1934 = Sabia yunnanensis Franch. in Bull. Soc. Bot. Fr. 33:465. 1886; Loes. in Ber. Deut. Bot. Ges. 32:543. 1914.

Celastrus mauritiana Stadtm. ex Willem. in Ust. Ann. Bot. 18:22. 1798; Roem. & Schult. Syst. Veg. 5:428. 1819—not *Celastrus* (leaves ternate).

Celastrus maytenus Willd. Sp. Pl. 1^2:1127. 1798 = Maytenus boaria Molina, Saggio Stor. Nat. Chile ed. 1. 177. 1778.

Celastrus mexicanus Moc. & Sessé ex DC. Prod. 2:8. 1825 = Wimmeria mexicana (Moc. & Sessé) Lundell in Bull. Torr. Bot. Club 67:618. 1940.

Celastrus micrantha Roxb. Hort. Beng. 86. 1814, nom. nud.; Fl. Ind. ed. Carey & Wall. 2:393. 1824—not *Celastrus* (leaves pinnate).

Celastrus mollis Decne. in Rev. Hort. II, 4:425. 1845–46—not *Celastrus* (leaves opposite).

Celastrus montana Roth ex Roem. & Schult. Syst. Veg. 5:427. 1819; Roth, Nov. Pl. Sp. 154. 1821=Gymnosporia montana Benth. Fl. Austral. 1:400. 1863.

Celastrus moya O. Kuntze, Rev. Gen. 3^2:37. 1898 = Moya spinosa Griseb. Pl. Lorentz. 63, *pl. 1, f. 3.* 1874.

Celastrus muelleri Benth. Fl. Austral. 1:399. 1863 = Maytenus sp.

Celastrus myrtifolius Linn. Sp. Pl. 196. 1753 = Prunus myrtifolia (Linn.) Urban, Syn. Ant. 5:93. 1904.

Celastrus neglecta Wall. Cat. no. 4341. 1831 = Gymnosporia neglecta Laws. in Hook. Fl. Brit. Ind. 1:619. 1875.

Celastrus nepalensis Steud. Nom. ed. 2, 1:315. 1840 = Pittosporum floribundum Wight & Arn. Prod. Ind. Orient. 154. 1834.

Celastrus obtusatus Presl, Bot. Bemerk. 34. 1844 = Simmondsia californica Nutt. in Hook. Lond. Jour. Bot. 3:400, *t. 16.* 1844.

Celastrus obtusifolia Roxb. Hort. Beng. 86. 1814, nom. nud.; Fl. Ind. ed. Carey & Wall. 2:393. 1824 = Gymnosporia trigyna Baker, Fl. Maurit. 50. 1877.

Celastrus octogonus L'Hér. Sêrt. 7. 1788 = Maytenus orbicularis (Willd.) Loes. in Engl. Bot. Jahrb. 50 (Beibl. 111):10. 1913.

Celastrus opposita Wall. in Roxb. Fl. Ind. ed. Carey & Wall. 2:398. 1824 = PLEUROSTYLIA COCHINCHINENSIS Pierre, Fl. For. Cochinch. Fasc. 20, sub. *t. 305*, in text. 1894.

Celastrus orbicularis Willd. mss. ex HBK. Nov. Gen. et Sp. Pl. 7:65. 1825 = MAYTENUS ORBICULARIS (Willd.) Loes. in Engl. Bot. Jahrb. 50(Beibl. 111):10. 1913.

Celastrus orixa Sieb. & Zucc. in Abh. Bayer. Akad. Muench. II, 4:150. 1845 = ORIXA JAPONICA Thunb. Nov. Gen. Pl. 3:57. 1783.

Celastrus ovalifolius Steud. Nom. Bot. ed. 2, 1:315. 1840 = GYMNOSPORIA OVATA Laws. in Hook. Fl. Brit. Ind. 1:619. 1875.

Celastrus ovatus Hill. Veg. Syst. 13:62, *f. 12*. 1824 = COLUBRINA FERRUGINOSA Brongn. in Ann. Sci. Nat. I, 10:369. 1827.

Celastrus ovatus Wall. Cat. no. 4308. 1831 = MAYTENUS OVATA (Wall.) Loes. in Engl. & Prantl, Nat. Pflanzenfam. 2 Aufl. 20b:140. 1942.

Celastrus oxyphyllus Wall. Cat. no. 4312. 1831 = GYMNOSPORIA ACUMINATA Hook. Fl. Brit. Ind. 1:619. 1875.

Celastrus pallidus Wall. Cat. no. 4307. 1831 = GYMNOSPORIA MONTANA Benth. Fl. Austral. 1:400. 1863.

Celastrus parviflorus Vahl, Symb. Bot. 1:21. 1790 = GYMNOSPORIA sp.

Celastrus parvifolius A. Rich. Ess. Fl. Cub. 349. 1845—not *Celastrus* (fruits 2-valved and 1- to 2-seeded).

Celastrus pauciflora Wall. in Roxb. Fl. Ind. ed. Carey & Wall. 2:400. 1824—not *Celastrus* (ovary 1-celled).

Celastrus pentagyna Zipp. ex Span. in Linnaea 15:186. 1841, nom. nud.

Celastrus quadrangulatus Schrad. in Goett. Gel. Anz. 1:716. 1821 = MAYTENUS QUADRANGULATUS (Schrad.) Loes. in Engl. & Prantl, Nat. Pflanzenfam. 2 Aufl. 20b:142. 1942.

Celastrus retusa Poir. in Lam. Encycl. Méth. Suppl. 2:146. 1811 = MAYTENUS RETUSA Briq. in Ann. Conserv. & Jard. Bot. Genève 20:351. 1919.

Celastrus rhombifolius Hook. & Arn. in Hook. Bot. Misc. 3:170. 1833 = IODINA RHOMBIFOLIA Hook. & Arn. ex Reissek, in Mart. Fl. Bras. 11^1:78. 1861.

Celastrus richardi Gomez de la Maza, Dicc. Bot. Nom. Vulg. 25. 1889 = MAYTENUS BUXIFOLIUS Griseb. Cat. Pl. Cub. 53. 1866.

Celastrus richardi γ. *latifolius* Gomez de la Maza in Ann. Soc. Españ. Hist. Nat. 19:239. 1890, nom. nud.

Celastrus richardi δ. *cochlearifolius* Gomez de la Maza, loc. cit. 239. 1890 = MAYTENUS COCHLEARIFOLIUS Griseb. Cat. Pl. Cub. 53. 1866.

Celastrus richardi ε. *elaeodendroides* Gomez de la Maza, loc. cit. 239. 1890 = MAYTENUS ELAEODENDROIDES Griseb. loc. cit. 54. 1866.

Celastrus rigida Wall. in Roxb. Fl. Ind. ed. Carey & Wall. 2:396. 1824 = GYMNOSPORIA WALLICHIANA Laws. in Hook. Fl. Brit. Ind. 1:621. 1875.

Celastrus robustus Roxb. Hort. Beng. 18. 1814, nom. nud.; Fl. Ind. ed. Carey & Wall. 2:395. 1824 = KURRIMIA sp.

Celastrus rothianus Wight & Arn. Prod. Fl. Ind. Orient. 1:159. 1834 = Gymnosporia rothiana Laws. in Hook. Fl. Brit. Ind. 1:620. 1875.

Celastrus royleanus Wall. Cat. no. 4317. 1831 = Gymnosporia royleana Laws. loc. cit. 620. 1875.

Celastrus rufa Wall. in Roxb. Fl. Ind. ed. Carey & Wall. 2:397. 1824 = Gymnosporia rufa Laws. loc. cit. 620. 1875.

Celastrus salicifolia Lévl. in Fedde, Rep. Sp. Nov. 13:263. 1914 = Ilex macrocarpa Oliv. in Hook. Icon. Pl. 18:*t. 1787*. 1888; Rehd. in Jour. Arnold Arb. 14:242. 1933.

Celastrus seguini Lévl. in Fedde, Rep. Spec. Nov. 13:262. 1914 = Myrsine semiserrata Wall. in Roxb. Fl. Ind. ed. Carey & Wall. 2:293. 1824.

Celastrus semiarillata Turcz in Bull. Soc. Nat. Mosc. 36^1:599. 1863—not *Celastrus* (branches spiny).

Celastrus sepiarius Dennst. Schlüs. Hort. Ind. Malab. 31. 1818, nom. nud.

Celastrus serrulatus Roth, Nov. Pl. Sp. 155. 1821, p. p. = Gymnosporia rothiana Laws. in Hook. Fl. Brit. Ind. 1:620. 1875.

Celastrus spicatus Vell. Fl. Flum. 92, *t. 138*. 1827 = Gouania corylifolia Raddi, in Mem. Soc. Ital. (Modena) 18, *f. 394*. 1820.

Celastrus spinifolius Larrañaga, Escritos D. A. Larrañaga 2:96. 1923—not *Celastrus* (capsules bivalved).

Celastrus spinosus Royle, Ill. Bot. Himal. 157. 1835 = Gymnosporia royleana Laws. in Hook. Fl. Brit. Ind. 1:620. 1875.

Celastrus striatus Thunb. Fl. Jap. 98. 1784 = Euonymus altus (Thunb.) Sieb. Syn. Pl. Oecon. Jap. 49. 1830.

Celastrus suaveolens Lévl. in Fedde, Rep. Sp. Nov. 13:263. 1914 = Ilex suaveolens (Lévl.) Loes. in Ber. Deut. Bot. Ges. 32:541. 1914.

Celastrus tetramerus Standley in Contr. U. S. Nat. Herb. 23:679. 1923 = Phyllanthus sp.

Celastrus tristis Lévl. in Fedde, Rep. Sp. Nov. 13:263. 1914 = Rhamnus napalensis (Wall.) Laws. in Hook. Fl. Brit. Ind. 1:640. 1875.

Celastrus uncinatus Ruiz & Pavon, Fl. Peruv. 3:7, *t. 230, f. a.* 1802 = Maytenus boaria Molina, Saggio Stor. Nat. Chile, ed. 1, 177. 1778.

Celastrus variabilis Hemsl. in Jour. Linn. Soc. 23:124. 1886 = Gymnosporia variabilis Loes. in Engl. Bot. Jahrb. 29:446. 1900.

Celastrus verticillata Roxb. Hort. Beng. 18. 1814, nom. nud.; Fl. Ind. ed. Carey & Wall. 2:391. 1824 = Pittosporum floribundum Wight & Arn. Prod. Fl. Ind. Orient. 154. 1834.

Celastrus verticillatus Ruiz & Pavon, Fl. Peruv. 3:6, *t. 229, f. b.* 1802 = Maytenus verticillatus DC. Prod. 2:10. 1825.

Celastrus vitiensis (A. Gray) [incorrectly ascribed to Benth. & Hook. by] Drake, Fl. Polyn. France, 30. 1893 = CATHA VITIENSIS A. Gray, Bot. Phanerog., Wilkes U. S. Expl. Exped. 287, *t. 23.* 1854 = GYMNOSPORIA VITIENSIS (A. Gray) Seem. Fl. Vit. 40. 1865.

Celastrus wallichianus Spreng. Syst. Veg. 5, Index 150. 1828 = GYMNOSPORIA WALLICHIANA Laws. in Hook. Fl. Brit. Ind. 1:621. 1875.

Celastrus wallichianus Wall. in Roxb. Fl. Ind. ed. Carey & Wall. 2:400. 1824 = GYMNOSPORIA WALLICHIANA Laws. in Hook. loc. cit. 621. 1875.

Celastrus wallichii G. Don, Gen. Syst. 2:8. 1832 = CELASTRUS LUCIDA Wall., non Linn.—not *Celastrus.*

Celastrus wightianus Wall. Cat. no. 4332. 1831 = PLEUROSTYLIA COCHINCHINENSIS Pierre, Fl. For. Cochinch. Fasc. 20, sub. *t. 305* in text. 1894.

Celastrus yunnanensis Lévl. Cat. Pl. Yun-Nan, 32. 1915 = PREMA PARVILIMBA P'ei in Mem. Sci. Soc. China 1:62. 1932; Rehd. in Jour. Arnold Arb. 15:324. 1934.

Celastrus zeylanica Roth ex Roem. & Schult. Syst. Veg. 5:427. 1819 = SCUTIA COMMERSONII Brongn. in Ann. Sci. Nat. I, 10:363. 1827.

ENUMERATION OF THE SPECIES

SUBGENUS I. CELASTRUS

SERIES 1. PANICULATI

1. *paniculatus* Willd.
   - 1a. ssp. *paniculatus*
   - 1b. ssp. *serratus* (Blanco) Ding Hou
   - 1c. ssp. *multiflorus* (Roxb.) Ding Hou
2. *novoguineensis* Merr. & Perry
3. *subspicatus* Hook. f.
4. *richii* A. Gray
5. *madagascariensis* Loes.
6. *angulatus* Maxim.
7. *scandens* Linn.

SERIES 2. AXILLARES

8. *monospermus* Roxb.
9. *monospermoides* Loes.
10. *hindsii* Benth.
11. *glaucophyllus* Rehd. & Wils.
12. *hookeri* Prain
13. *membranifolius* Prain
14. *vanioti* (Lévl.) Rehd.
15. *hypoleucus* (Oliver) Warburg
16. *gemmatus* Loes.
17. *orbiculatus* Thunb.
18. *rosthornianus* Loes.
19. *punctatus* Thunb.
20. *kusanoi* Hayata
21. *hirsutus* Comber
22. *stylosus* Wall.
    - 22a. ssp. *stylosus*
    - 22b. ssp. *glaber* Ding Hou
23. *aculeatus* Merr.
24. *flagellaris* Rupr.

SUBGENUS II. RACEMOCELASTRUS

25. *lenticellatus* Lundell
26. *racemosus* (Reiss.) Loes.
27. *panamensis* Lundell
28. *pringlei* Rose
29. *vulcanicolus* Donn. Smith
30. *caseariifolius* Lundell
31. *meridensis* Pittier

Index to Exsiccatae

Italicized numerals refer to collectors' numbers, *s. n. (sine numero)* to unnumbered collections; parenthetical numerals refer to the numerals of the species conserved in this revision.

Adams, J. W. *1326, 1656, 2865, 5016* (7).
Adams, J. W. & M. L. T. *1426, 2131* (7).
Adams, J. W., M. L. T. Adams & E. T. Wherry *1519* (7).
Adams, J. W. & G. Hopkins *907* (7).
Adams, J. W. & R. Tash *568* (7).
Adams, J. W. & E. T. Wherry *2300* (7).
Ahern's collector *2889* (Bureau of Sci. no.) (1b).
Alcasid, —, & G. E. Edaño *4699* (1b).
Alims, —. *1605, 2103* (9).
Allard, H. A. *473, 5654* (7).
D'Alleizette, Ch. *1288* (5).
Allen, P. H. *319* (27).
Anderson, T. *104* (22a); *107, 108, 109* (8).
Andrews, D. W. *39* (7).

Backer, C. A. *37252* (1c).
Bacon, E. S. *s. n.* (7).
Baenitz, C. *1118* (7).
Balansa, M. *1870* (3).
Ballard, C. A. *s. n.* (7).
Barber, C. A. *6846, 7018* (1a).
Barnhart, J. H. *580, 1194, 1394* (7).
Bartlett, H. H. *6864* (9).
Batchelder, C. F. *s. n.* (7).
Bennett, W. M. *419, 1842, 2223, 5690, 5720, 6308, 6902, 7923, 8682* (7).
Bergman, H. F. *2101, 2630, 2855, 3120* (7).
Bergman, S. *439* (17).
Berkheimer, D. *4756* (7).
Bicknell, E. P. *3836* (7).
Biswas, K. *2033* (8).
Bock, C. & A. v. Rosthorn *790* (6).
Bohlin, B. *104* (17).
Boswastore, —. *73* (22a).
Brandis, —. *2032* (1a).
Brass, L. J. *12999* (9).
Breitung, A. J. *6172* (7).
Brooks, W. P. *44, 544* (17).
Bush, B. F. *118, 732* (7).
Bush, Y. *60* (7).

Calder, C. C. & M. S. Ramaswami *654* (1a).
Carr, C. E. *11260* (3); *13036* (9); *15698* (2).
Carlson, M. C. *900* (29).
Carter, H. G. *466* (1c).
Cavalerie, J. *496* (18); *3976* (10).
Chandler, H. P. *510* (7).
Chase, V. H. *255, 853, 4057, 16652* (7).
Chen, P. E. *2447, 2701* (19).
Chen, Y. *1090* (18).
Cheng, C. H. *1573* (23).
Cheo, T. Y. & L. Yen *193* (17).
Chiao, C. Y. *1720* (18); *1721* (11); *2116, 2126, 2395, 2612, 3016* (17); *18641* (22b); *18768* (23).
Chiao, C. Y. & C. S. Fan *458* (10); *767* (11).
Chien, S. S. *5920* (18).
Ching, R. C. *1336, 1664* (23); *1677* (19); *2508* (23); *2638* (16); *2661* (19); *2700* (11); *2845* (22b); *3065* (15); *3165, 5461* (22b); *6057* (14); *7080* (22b); *7120, 7525* (8); *7566* (16); *8205* (22b); *8433* (8); *20489, 20638* (11); *20682* (16); *21618, 22042* (11); *22119* (18).
Ching, —. & —. Tso *580* (17).
Chou, K. H. *8215, 8460* (23).
Chow, C. L. *5707* (18); *6448, 6468* (11).
Chow, H. C. *315* (18); *369* (17); *405, 495* (6); *548* (10); *572* (18); *597* (6); *705* (10); *901* (16); *1436* (11); *1944* (10); *2005* (6); *7597* (11); *8639* (10); *8028* (11); *9906* (16); *11712* (10); *11742, 12013* (18).
Chu, K. L. *3701* (18); *3761* (16).
Chun, N. K. *40143, 40276* (8); *42959* (16).
Chun, N. K. & C. L. Tso *44028* (20); *44165, 44169* (8).
Chun, W. Y. *3107* (8); *3503* (17); *3570* (18); *3724* (6); *3884* (16); *4066* (6); *4427* (15); *4229* (16); *4831* (8); *4840* (10); *4943* (8); *5013* (16); *5539* (23).
Chun, W. Y. & S. S. Chien *8050* (6).
Chung, H. H. *335* (10); *493* (19); *954, 1084, 1174, 1206* (10); *1437, 1447, 1491* (19); *1514* (23); *1515* (19); *1693* (23); *1771* (10); *1773, 2065, 3085, 4036* (23); *4599* (10); *4604* (19); *4774, 4777* (23); *4783, 4851* (10); *5341* (19); *5601* (10); *5954* (23); *5957, 5977* (19); *6232* (10); *6235, 7264* (23); *8436, 8446* (10).
Chung, H. H. & S. C. Sun *592* (16).
Chung, Z. S. *83605* (16).
Clarke, C. B. *682c* (12); *5615* (10); *12046* (22a); *18678C* (22a); *23681B, 24857, 26339* (1a); *26701B* (22a); *27040D* (12); *27683* (8); *35758E* (12); *37949B* (8); *41911C* (10); *45152* (8); *46569* (12).
Clemens, J. & M. S. Clemens *3523* (2); *4581, 5084* (9); *5152, 5394* (2); *6253* (9); *6606, 7230* (2); *27879* (9); *28701, 28701A* (10); *29919* (9); *30493* (10);

31827, 32052, 32120, 32860, 33182, 50253, 50641, 51295 (9).
Clemens, M. S. *11073* (2); *11680* (7); *43683* (3).
Clokey, I. W. *2479* (7).
Coert, J. H. *3758* (1b).
Colani, E. *4049* (1c).
Collett, H. *588, 672* (1a).
Corbett, —. & —. Williams *88* (7).
Core, E. L. *3778* (7).
Cory, V. L. *14152* (7).
Cuatrecasas, J. *1813* (31).
Cuiran, H. M. *7499* (1b).
Cuming, H. *1209, 1324* (1b).
Curran, H. *3415* (1b).
Curtis, C. *404, 2005* (9).

Daniel, H. *3295* (31).
Darsteri, A. C. *17* (8).
David, A. *1783* (17).
Davis, John. *199, 716, 720, 3709, 6368, 7344* (7).
Day, M. A. *43, 96* (7).
Deam, Chas. C. *15456, 18042, 18240, 18331, 18810, 19320, 35238, 37914, 38141* (7).
Degener, Otto *14798, 14940, 14973, 14978, 15050, 15315, 15330, 15352, 15424, 15427* (4).
Demaree, D. *6746, 6955, 11349, 11572* (7).
Deplanch, —. *92* (3).
Desiloa, F. *s. n.* (8).
Dickason, F. G. *5845* (1a).
Dickey, S. S. *27* (7).
Dorgelo, J. D. *2290* (1c).
Dorsett, P. H. & W. J. Morse *619* (24); *1070, 7074, 7152, 7206* (17).
Dougboo, —. *86225* (12).
Drummond, J. R. *21515, 21516, 21651, 21691* (1a).
Ducloux, F. *132* (16).
Dudgeon, W. & L. A. Kenoyer *237* (1a).
Dunn, —. *44* (19); *2479, 2479B, 3420* (23).
Duthie, I. F. *8211* (1a).

Eccles, R. G. *29* (7).
Edaño, G. E. *999* (9); *11599* (1b).
Edmondson, T. W. *3426, 3876* (7).
Eggleston, W. W. & K. M. Wiegand *22503* (7).
Elizabeth, E. E. *3511, 3903* (7).
Elmer, A. D. E. *11411* (9).
Elwell, L. H. *202, 203* (7).
Emig, W. H. *370* (7).
Endert, F. H. *3846* (9).
Enequist, J. *435* (7).
Engelmann, G. *1107* (7).
Esquirol, J. *4* (16).
Evans, I. H. N. *13247* (1c).
Evers, R. A. *143* (7).
Evers, R. A., G. N. Jones & F. F. Jones *541* (7).
Eyles, D. E. & M. S. Eyles *8505* (7).
Eyles, M. S. *8380* (7).

Faber, E. *227* (18).
Fan, C. S. & Y. Y. Li *190* (22b); *210, 236* (11); *263* (22b).
Fang, W. P. *571* (6); *593* (16); *1202a* (11); *1362* (6); *2124* (16); *3089* (11); *3424, 3486* (18); *3737, 4176* (11); *5529* (16); *5589* (18); *12883, 13051* (11); *14981* (10); *15211* (22b); *15221* (10); *15280* (22b); *16419* (18); *16624, 17317* (11); *17795, 19884* (18).
Fang, W. P. & T. C. Lee *3575* (16).
Faurie, U. *1374* (20); *1376* (10); *2502, 6133, 6134* (17); *8015* (19).
Fay, M. J. *208* (7).
Fender, F. S. *543, 556, 615, 616, 863, 1158, 1329, 1411, 3264* (7).
Fendler, A. *104* (7).
Feng, K. M. *747* (22b); *787, 1226* (11); *2428, 2479* (18); *2868* (16); *3047* (11); *3262* (18); *3299* (11); *3365* (22b); *11445, 11530* (8); *11685* (10); *11720* (18); *11830* (8); *11682* (10); *12084* (18); *12260, 12283* (22b); *12469* (8); *12727* (22b); *13068* (10); *13124* (18); *13210* (10); *13369* (18); *13387, 13454, 13464* (10); *13472, 13749* (8); *13765* (21); *13847* (10).
Fenzel, G. *502* (17); *678, 738* (6); *927* (15); *2817* (6); *2827* (17).
Fernald, M. L. *167, 2709* (7).
Fernald, M. L. & B. Long *9858, 9859, 12716, 13680, 13973, 14031* (7).
Fester, G. S. *1288* (7).
Fischer, C. E. C. *4739* (1a).
Fogg, J. M., Jr. *5807, 8605, 7410, 8213, 8554, 10269, 12293, 12527, 13032, 14678, 14835* (7).
Forbes, H. O. *921, 961, 980, 980a* (10); *3829* (22a).
Forrest, G. *7812* (18); *8704* (16); *9396* (22b); *9948, 10069, 10142, 11152* (11); *11173* (16); *11874* (8); *12050, 14510* (16); *15980* (22b); *16226* (18); *16241* (16); *16538* (11); *17496* (21); *21201* (18); *21464* (16); *22235* (11); *22311* (16); *22475, 23230* (11); *26407* (8).
Fosberg, F. R. *15146* (7).
Fox, R. B. *4864* (1b).

Friesner, R. C. *11711* (7).
Fung, H. *00161* (8); *A-551* (10).

Galen, J. *480* (7).
Gamble, J. S. *8780* (1a).
Gamble, N. *1926A* (12).
Gammie, G. A. *1179* (12).
Gates, —. *7468* (1b).
Gates, F. C. *15880, 18744* (7).
Gehriger, —. *298* (31).
Gilbert, F. A. *187* (7).
Gilbert, F. A. & C. R. Gilbert *285* (7).
Gilbert, K. S. *6* (17).
Gillespie, J. W. *4182* (4).
Gleason, H. A. *9213* (7).
Gleason, H. A., Jr. *639* (7).
Goering, —. *88* (19).
Grant, M. L. *2973* (7).
Grassl, C. O. *2250, 3218* (7).
Greenman, J. M. *783, 837, 2409, 2510* (7).
Greenman, J. M., O. E. Lansing, Jr. & R. A. Dixon *44* (7).
Greenwood, W. *900* (4).
Gress, J. L. *2018* (7).
Gressitt, J. L. *141, 185* (19); *1240* (20); *1767* (23).
Griffith, —. *605* (12); *666, 1992* (8).
Groff, G. W. *6132* (1c).
Grood, J. H. *799* (7).

Hallier, —. *462* (10).
Hance, H. F. *370, 22191* (10).
Handel-Mazzetti, H. *132* (6); *583, 810, 1305, 2008* (18); *5692* (6); *1307* (16).
Haneeff, Md. & Md. Jan *2446* (9).
Harbison, T. G. *1611* (7).
Harsukh, —. *21400* (1a).
Hayden, A. *9590, 10070* (7).
Hayward, H. E. *616* (7).
Heiser, Charles B., Jr. *1801* (7).
Heller, A. A. & E. G. Halbach *522* (7).
Henrici, S. *1151* (7).
Henry, A. *0986a* (11); *1893* (20); *2084* (6); *2837* (15); *3115* (18); *3241* (10); *3405* (6); *3495, 3495A, 3856* (10); *3883* (6); *5559* (22b); *5640, 5734* (18); *5887* (15); *5909* (18); *5925a* (6); *5986* (11); *5986a* (18); *6771, 6811* (15); *7614* (16); *9679, 9679A* (11); *9782, 9782A* (16); *10446* (8); *10522* (22b); *10531* (16); *10559* (10); *10955* (8); *11267* (22b); *11399* (8); *11471* (16); *11572* (1a); *11972* (8); *11972A* (1c); *11972B* (8); *11972C* (10); *11993, 11993A, 12122, 12122A, 12122B* (1c); *12572* (1a); *12572A, 12572B* (1c).

Hermann, F. J. *1820* (7).
Hers, J. *26* (17); *269* (6); *345* (17); *417* (6); *619, 704* (17); *772* (6); *828* (17); *861* (6); *1272* (17); *1288, 1314, 1712* (6); *1758* (17); *1831, 2442, 2670* (6); *2791, 2795* (17); *2932, 3010, 3097* (6).
Hieronymus, P. *443* (1a).
Hinckley, L. C. *1108* (7).
Hinton, G. B. *290, 3506, 3574, 3717, 6076, 7230, 7380, 9020* (28).
Hitchcock, A. S. *60* (7).
Ho, H. T. *60086* (8).
Hooper, D. *38801, 39537* (1a).
Hopkinson, —. *297* (18).
Horne, J. *1135* (4).
Horr, W. H. & R. L. McGregor *E493* (7).
Horsey, R. E. *290, 1283, 1488, 1545, 1581, 1748, 1754, 2258, 2380* (7).
How, F. C. *70368* (10); *70573* (1c); *73564* (8).
How, F. C. & N. K. Chun *70273* (8).
Hsiung, Y. K. *5516* (23); *5655, 5701* (16); *5718* (23).
Hu, H. H. *784, 889* (23); *1119, 1585* (16); *1631* (24).
Hu, W. K. *7380* (11).
Huk, A. *62* (1a).
Hunnewell, F. W. *5685* (7).
Hurusawa, I. *10650* (17).

Ip, N. K. *41* (22b).

Jack, J. G. *3857* (7).
Janet, —. *A79, A348, A349, 1639* (17).
Jenkins, P. H. & G. L. Stebbins, Jr. *170* (7).
John, A. *476* (27).
John, H. S. *735, 2795* (7).
Johnson, F. W. *249, 1867* (7).
Jones, G. N. *11456, 13861, 16251* (7).
Junghuhn, —. *27, 105* (10).

Kanehira, R. & S. Hatusima *12102* (9).
Kang, —. *174* (17).
Kanjilal, Upendranath *3801* (8); *4976* (10).
Kasin, —. *347* (1c).
Kawakami, T. & U. Mori *3145* (20).
Keith, —. *213* (213).
Kellogg, J. H. *389* (7).
Keng, Y. L. *73, 285* (23); *576* (19).
Kerr, A. F. G. *9941* (10).
Khalil, A. *s. n.* (1a).
Khan, B. *11* (1c); *36, 259* (1a).
Kiener, W. *17023* (7).

Kimura, Y. *307* (17).
King, G. *s.n.* (1a); *2134* (8).
Dr. King's collector *s.n.* (1a); *178, 233* (8); *454, 479* (1a); *5690, 6928* (9).
Kirk, M. D. *307* (7).
Kjellberg, G. *2311* (9); *2907* (1b).
Ko, S. P. *50089, 51463* (8); *55544* (22b); *56089* (10).
Koelz, W. *4266, 4377* (1a).
Koorders, S. H. *19632β* (1b); *27372β, 29803β* (1c); *30178β* (1b); *42439β* (1b).
Korthals, —. *747* (10).
Kostermans, A. *441, 1027* (1c).
Krotkov, P. V. *7587, 9197* (7).
Kudo, Y. & S. Suzuki *16048* (20).
Kuhl, —. & Van Hasselt *18* (1c).
Kurz, S. *65* (1a); *171* (22a); *182* (8); *1926* (1a); *1927* (1c).

Lace, J. H. *2229* (8); *3130, 3280* (1a); *5753, 5775* (12).
Lakela, O. *3018* (7).
Lam, H. J. *2466* (1c).
Lambert, B. B. *12* (7).
Lansing, O. E., Jr. *3525* (7).
Lau, S. K. *283* (1c); *693* (10); *800* (8); *2672* (10); *2750* (8); *3191, 3658* (1c); *3711* (8); *4367, 4801* (23); *26184* (20); *26227* (10); *26285* (8); *26606* (20); *26624* (8); *28207, 28558, 28707, 28763* (18); *20043*.
Laybourn, W. A. *4* (7).
Leavenworth, W. C. & H. Hoogstraal *1023* (28).
Lee, T. C. *2805, 3069* (18); *3168* (22b); *3561* (11); *4551* (10).
Leeuwen, W. M. Docters v. *11098* (2).
Lehmann, —. *399, s.n.* (30).
Lei, C. I. *129* (10); *309* (20); *440* (10).
Levine, C. O. *180, 240, 441, 484, 1236* (CCC nos., 10).
Li, C. F *11169* (17).
Li, M. K. *1181* (22b); *2807, 2947* (1c).
Li, T. F. *69* (17).
Liang, H. Y. *62583* (8); *63042* (1c); *63419* (8); *63892* (1c); *65293* (8).
Licent, E. *13262* (17).
Liebmann, —. *14871, 14872, 14873, 14874, 14875, 14875a, 14875b* (26).
Lin, Y. T. *11677* (23).
Ling, K. *1159* (16); *1194* (22b); *1246, 1349* (16); *1402, 1607, 1664, 2197* (17).
Liou, K. M. *385* (17).
Lippincott, C. D. *26* (7).
Lisi, A. G. *30* (7).
Lister, J. L. *68* (10); *157* (22a).
Liu, J. C. *398, 1176* (17).
Liu, Y. & C. W. Wang *82947* (8).
Liu, Y. S. *1147* (16); *1184* (22b); *1319* (18); *1423* (16); *1714* (22b); *2231* (11).
Lloyd, C. G. *480* (7).
Long, B. *3498, 5700, 8273, 9798, 13988, 14264, 14380, 15412, 15616, 16886, 17750, 18211, 18231, 18743, 18750, 19331, 19554, 19747, 20887, 20921, 21818, 22802, 23299, 24117, 25248, 26601, 26661, 27032, 27965, 28195, 29256, 29891, 30948, 31319, 31656, 31910, 33202, 33250, 33572, 34655, 35526, 37261, 38396, 38632, 38876, 39362, 40005, 40225, 42511, 48957, 52212, 53034, 53957, 54162, 54300, 54659, 55338, 55447, 55517, 56020, 59108, 62352, 62569, 64027, 65675, 66853, 66944, 67213* (7).
Lundell, C. L. *6307* (26).
MacElwee, A. *2072* (7).
Mackenzie, K. K. *4764* (7).
Macoun, —. *361* (7).
Maire, E. E. *14* (16); *22* (6); *81* (18); *102* (16); *254* (18); *385, 393* (6); *1986, 3633* (18); *3914, 6224* (6); *7256* (18).
Marie-Victorin *16289, 18534* (7).
Marie-Victorin & Rolland-Germain *45524, 49811* (7).
Marie-Victorin, Rolland-Germain & M. Raymond *56097* (7).
Maries, C. *22* (1a).
Martens, J. W. *65* (7).
Matuda, E. *0529, 5148, 16369* (29).
McClure, F. A. *3544, 7938* (10); *9182* (1c).
McClure, F. A. & Chan Kwai Shang *4* (23).
McCoy, S. *3805* (7).
McCree, H., Jr. *711* (7).
McGregor, R. C. *11275* (1b).
McGregor, R. L. *645* (7).
McVaugh, R. *220, 605, 759* (7); *10246, 10308, 13906* (28).
Meebold, A. *8055* (1a); *15912* (22a).
Merrill, E. D. *944* (1b); *9311* (1c); *10070, 10212* (10).
Merrill, E. D. et al. *15640* (29).
Merrill, G. M. *323, 1019* (7).
Metcalf, F. P. *2030, 2082* (7).
Metcalf, F. P. & J. C. Chang *605, 718* (10); *723* (19).
Metz, —. *1549* (1a).
Meyer, F. N. *1722* (6).
Minshall, W. H. *129, 300, 3590* (7).

Mizushima, M. *1929* (17).
Mokim, Shaik *266* (1c).
Moldenke, H. N. *1623, 2852* (7).
Montgomery, F. H. *649* (7).
Moore, H. E. *2968* (29).
Morris, E. L. *1175, 1432* (7).
Morrison, J. L. *1119* (7).
Mousset, J. P. *1111* (1b).
Moyle, J. B. *411* (7).
Muenscher, W. C. & A. R. Bechtel *264* (7).
Muenscher, W. C. & R. T. Clausen *4680* (7).
Mukherjee, Revoti Mohon *32* (1a).
Mumbauer, J. R. *359* (7).

Nakamura, T. *3618* (19).
Narayanaswami, V. *105* (1a).
Nath, Amar *24* (1a).
Norton, J. B. 60^{a} (7); *1346* (20).

Ohwi, J. *436* (17).
Ohwi, J. & Okamoto, K. *504, 506* (17).
Oldham, R. *161* (19); *162* (17).
Ome, Tsuro (?) *500* (19).
Otanes, F. *17985* (1b).
Ownbey, M. *1510* (7).

Painter, J. H. *1194* (7).
Palmer, E. *106* (28).
Palmer, E. J. *712, 772, 13993, 15237, 16145, 18923, 21238, 22124, 22814, 26057, 26960, 27583, 28521, 28785, 30917, 31134, 32933, 34170, 35954, 36053, 36900, 37131, 41926-A, 43587, 45308, 45570, 45645, 49016* (7)
Pammel, L. H. *43, 269* (7).
Pammel, L. H., H. H. Hume & S. R. Fitz *1647* (7).
Pammel, L. H., H. E. Pammel & P. S. Mc-Nutt *522* (7).
Paradhan, K. S. *34* (1a).
Parham, H. B. R. (Mrs.) *3* (4).
Pease, A. S. *14, 3410, 3671, 11963* (7).
Peattie, D. C. *48A* (7).
Pennell, F. W. *1148, 16382, 16487* (7).
Pételot, A. *340, 863, 991* (10); *3184* (8); *5829* (22b); *5931* (8); *5936* (21); *5941* (11); *5946* (22b); *6368* (8).
Peters, J. E. *29* (7).
Phelps, O. P. *647, 648* (7).
Pierre, L. *895* (1a); *2794* (1c).
Poilane, —. *28714* (10).
Poole, S. F. *102* (7).
Pradham, —. *34* (1a).
Dr. Prain's collector *70, 78* (1a); *289* (12); *439* (22a); *795, 1002* (8).
Pratt, —. *65* (7).

Prazer, J. C. *54, 167* (1a); *236* (1c); *273* (1a).
Pretz, H. W. *11403* (7).
Pringle, C. G. *6842, 6998* (28); *8133* (26).
Purdom, W. *944, 945* (17); *946,* 946^{b} (6).
Purpus, C. A. *7094* (26); *7370* (25); *8080, 8926* (26).

Ram, B. *309* (1a).
Ramaswami, M. S. *1490* (1a).
Ramos, M. & Deroy, D. *22511* (1b).
Ramos, M. & G. Edaño *38961* (9).
Ramos, R. *9, 346, 1813, 42711* (1b).
Randolph, L. F. & F. R. Randolph *35* (7).
Rao, M. R. *1588* (1a).
Raup, H. M. *7486, 7568* (7).
Redfield, I. H. *1061* (7).
Reko, B. P. *4019* (29).
Richards, C. D. *2453* (7).
Ridley, H. N. *404, 5237, 7127, 8228, 13538* (9).
Robinson, B. L. *550, 798, 831* (7).
Robinson, C. B. *11617* (1b).
Robbins, G. T. *2292* (7).
Rock, J. F. *71, 1024* (8); *1744* (10); *2237, 2770, 2823, 2900* (8); *3556* (11); *3799* (16); *3885* (18); *3931, 4032* (11); *4195, 6809* (16); *6946* (18); *7568* (16); *8312* (18); *8540* (11); *24679* (16).
Rodger, A. *198* (1c).
Rodriguez, G. *2025* (1a).
Rogers, C. Gilbert *864* (1c).
Rose, D. K. *3* (7).
Rosendahl, C. O. *315* (7).
Rosthorn, A. v. *9* (10); *1556b* (22b); *1572, 1573* (18).
Rydberg, P. A. *38, 1453* (7).
Rydberg, P. A. & —. Ralphlmer *1237* (7).
Ruth, A. *82, 356, 369* (7).

Samnasena, N. S. *34* (1a).
Santapau, H. *87.6, 87.7, 87.8, 87.9, 515, 570, 603, 1229, 1235, 1967, 1968, 1975, 2100, 4102, 8710, 12707, 12708, 14258* (1a).
Sawada, T. *2161* (17).
Schaeffer, R. L., Jr. *3503, 5881, 7721, 8770, 8776, 8777, 9821, 9979, 14728, 15100, 20521, 25023, 29418, 30116, 31768, 32768, 33851, 37752, 40474* (7).
Schneider, C. *644, 646, 647, 1027* (11); *1131, 1375* (18); *1984, 2839* (11); *2683* (18); *2874, 4112, 4130* (11).
Seymour, F. C. *1268* (7).

Shanks, R. E., A. J. Sharp & E. Clebach *5058* (7).
Shannon, J. I. *134* (7).
Sharp, A. J., E. Clebach & A. Clebach *6309* (7).
Sharp, A. J., S. Fairchild & E. Clebach *8254* (7).
Sherff, E. E. *1604* (7).
Shiota, K. *3899, 3905, 9643, 9766* (17).
Silvestri, C. *1336, 5099* (6).
Sin, S. S. *11835* (16); *11889* (23).
Sinclair, J. *39284* (9).
Singh, A. *25* (1a).
Singh, U. *43* (1a).
Smith, — & — Cave *964* (22a).
Smith, A. C. *1122, 4301, 5827, 6085* (4).
Smith, H. *740, 959, 5745, 6154, 7697* (17); *12898* (16); *13326* (11); *13448* (6).
Smith, H. H. *7142, 7785* (7).
Smith, U. C. *244* (7).
Soper, J. H. *2457, 2599* (7).
Sowett, H. B. S. *752* (1c).
Spire, —. *289* (1c).
Standley, P. C. *40524* (7); *71349* (26).
Standley, P. C. & J. Valerio *52024* (26).
Steenis, C. G. G. J. van *8717, 9651* (9).
Stevens, G. W. *1351, 1824, 4173* (7).
Steward, A. N. *1234, 5470* (16).
Steward, A. N. & H. C. Cheo *87, 396* (22b); *429* (18).
Steward, A. N. *et al.* *97, 541* (6).
Stewart, C. C. *1974* (7).
Stewart, R. R. *11118* (1a).
Steyermark, J. A. *887, 7572, 12131, 12875, 13583, 20596, 20825, 22955, 23533, 24382, 24489, 24563, 24679, 24874, 25065, 26348* (7); *57015* (26).
Stocks, J. E. *231* (1a).
Stone, W. *3821, 3921, 10200, 10682, 10847, 13319, 13375* (7).
Strachey, R. & J. E. Winterbottom *2* (1a).
Strathdickie, L. *1124* (3).
Stresemann, E. *90* (9).
Sulit, M. D. *3188, 3421, 9917, 10086* (9).
Sun, C. L. *781, 1247* (16).
Sun, S. C. *1189* (22b); *108* (17); *1189* (11).
Suzuki, S. *11162* (10); *444020, 455009, 479013, 486024, 493027* (17).
Suzuki, T. *6195* (20).
Swartley, J. C. *425* (7).

Taam, Y. W. *578* (10); *720* (8); *724* (23); *759* (10); *1041* (23); *1477* (10); *1792* (8); *1798, 1951* (10); *2087* (8); *2147* (10).
Tai, F. C. & C. M. Feng *5238* (22b).
Tai, F. C. *et al.* *5142* (11).
Tai, L. Y. *204, 1071* (11); *1113, 1120* (16).
Tang, C. C. & S. E. Ma *2936* (23).
Tang, S. G. *1677* (19); *6991, 7039* (10); *7085, 13657* (19); *15609* (23).
Tang, T. *889* (17).
Tanger, —. *4674* (7).
Taquet, T. *632, 2723* (24).
Tatnall, R. R. *2098, 3633, 4770, 4961, 4992* (7).
Taylor, T. M. C. *et al.* *1239* (7).
Ten, S. *40, 358, 550* (11).
Teng, S. W. *90254* (16); *90315* (6).
Teysmann, J. E. *8731* (1b).
Thomson, —. *740* (1a).
Thone, F. H. *214* (7).
Thwaites, C. P. *1232* (1a).
To, K. P. *1868* (10).
To, K. P. & K. C. Wong *2784* (20).
To, K. P. *et al.* *131, 442* (20); *473* (8); *631* (23); *889* (10).
Tolstead, W. L. *41881* (7).
Toppin, S. M. *4292, 6154* (10).
Toroes, R. S. *4009* (9).
Tso, C. L. *21152* (6).
Travis, M. T. *2871* (7).
Trelease, W. *62, 63* (7).
True, R. H. *92, 1148* (7).
True, R. H. & J. K. Edwards *5396* (7).
Tsai, H. T. *51340, 51343* (18); *51546, 51591, 51730* (8); *51945* (21); *52375* (10); *52477* (8); *52545* (10); *52552* (8); *52901* (18); *54026* (11); *54563, 54578* (22b); *54799* (21); *54949* (22b); *55076, 55139* (8); *55421* (21); *55679* (8); *56096* (18); *56342* (10); *56917* (8); *57253, 57271, 57343, 57510, 57769* (18); *57899* (11); *57974* (18); *58555* (11); *59523* (16); *59548* (18); *59799* (16); *59824* (11); *60152* (8); *60261* (21); *60420* (22b); *60459* (8); *60499* (21); *60781* (18); *60919* (22b); *60933* (18); *61004* (11); *61156, 61629* (22b); *61680* (8); *61753* (18); *62295* (8); *62396* (21); *62841* (22b); *63059* (18); *63116* (16).
Tsang, W. T. *77, 16566* (10); *20092* (23); *20209, 20604* (10); *20813* (6); *20855* (16); *21189, 21416* (23); *21422* (10); *21751, 22079* (8); *23574* (23); *24106* (8); *24131* (22b); *24188, 24735* (8); *23019* (10); *25189* (16); *25268* (23); *26404* (16); *27666* (6); *28365* (22b); *28843* (23); *28927* (20); *38365* (22b).
Tsang, W. T. & —. Fung *241* (10).

Tsang, W. T. & K. C. Wong *2661* (10); *2681* (8); *2928* (20).
Tsiang, Y. *720* (8); *1002* (10); *1346* (16); *1393* (20); *1419* (16); *1644, 1637* (10); *1705* (8); *1919, 2300* (10); *4061* (16); *4945, 4970* (6); *5013, 5360* (16); *5543, 5601, 5614* (18); *6450* (16); *6832* (22b); *7499* (18); *8653* (6); *9354, 9513* (18); *10047* (16); *10460* (23).
Tso, C. L. *20788, 20796, 21026* (20); *21152* (6); *21640* (23).
Tso, C. L. & Y. Tsiang *2040* (10).
Tsoong, —. *82941* (22b).
Tsui, T. M. *154* (23); *348* (8); *391* (10); *542* (18); *763* (16).
Turner, —. *431* (7).

Uno, K. *21823* (24).

Valeton, T. *102* (10).
Versteegh, —. *1643* (9).
Vicary (?), —. *175* (1a).
Visher, S. S. *2110* (7).
Voogd, C. N. H. de *682, 2338* (1b).

Wadmond, S. C. *425* (7).
Wagner, —. *6816* (7).
Wahl, H. A. *4959* (7).
Walker, E. H. *5717* (17).
Wallich, N. *4311* (8).
Walter, N. & C. M. Bangham *870* (10).
Wang, C. *32148* (18); *33029* (1c); *35222, 35893, 36064, 36607, 40415* (8).
Wang, C. W. *62839* (11); *62990, 63709* (16); *64147, 68293* (18); *68718* (1a); *69361, 71910* (18); *72857* (8); *72996* (1a); *73415, 73579, 73590, 73825, 73839, 74430* (8); *74570* (1a); *74650* (1a); *74907* (8); *74966* (1c); *75024* (1a); *75183* (8); *75551* (1a); *75846* (10); *75920* (8); *76355, 76644* (1a); *77202a* (8); *77541, 77833* (1c); *78458, 79015, 79459* (8); *79467, 79470* (10); *79560* (1c); *79776* (8); *80136, 80181* (10); *80194* (1c); *80232* (10); *80312* (8); *80588, 80781* (8); *81177* (10).
Wang, C. W. & Y. Liu *82917* (8).
Wang, F. T. *21124* (11); *21670* (6); *22451* (16); *22462* (11); *22633* (6); *22643* (11).
Wang, K. M. *3191* (10).
Wang, T. H. *114* (18); *299, 399* (16).
Wang, T. P. *176* (17).
Wang, W. H. *8096* (10).
Wang, Y. K. *3056* (8); *3060* (23); *3196* (10).
Ward, F. K. *9362* (21); *9455* (12).
Waterfall, U. T. *1715, 2830* (7).
Watkins, I. *51* (7).
Watson, J. *176* (1a).
White, C. T. *1943, 12517* (3).
Whitford, H. N. *81, 414* (1b).
Whitney, E. G. *2311* (7).
Wiegand, K. M. *2765, 6794, 10248* (7).
Williams, L. O. & A. Molina R. *10* (29).
Wilson, E. H. *181* (17); *357* (11); *357A* (18); *362* (15); *363* (16); *364, 364a, b* (6); *450* (10); *467* (6); *502* (16); *503, 560* (18); *561, 561A* (10); *688, 706* (18); *706b* (11); *753, 753A* (6); *919* (16); *952, 952A, 972* (11); *1063* (15); *1106, 1148* (11); *1175* (18); *1176* (14); *1184* (22b); *1289* (15); *1302, 1519, 2305, 2305A* (16); *2306* (15); *2307* (10); *2308* (17); *2309* (18); *2310* (11); *2311* (18); *2312* (14); *2215a* (16); *3324* (10); *3325, 4117, 4122, 4157* (11); *4187, 4195* (18); *4317* (11); *4781* (18); *4782* (11); *6121, 6304* (19); *6627, 6907, 7412* (17); *8300* (10); *8450* (24); *8611, 8801, 9203* (17); *9981* (20); *10425* (24); *10461* (17); *11096* (19); *11214* (20).
Winckel, W. F. *92β, 98β, 1633β, 1682β* (10).
Wood, C. E., Jr. *2710, 3383, 3784* (7).
Wray, L., Jr. *175, 1031* (9).
Wright, C. *9* (8); *54* (19); *91* (10); *92* (8); *611* (10).

Yamada, K. *1215* (20).
Yamamoto, Y. *802* (19).
Yamazala, T. *44, 44-A* (17).
York, H. H. *155* (7).
Yu, T. T. *445* (22b); *750, 940, 951* (11); *1756* (18); *5522* (11); *5562, 5771* (16); *5845, 7204, 7978, 8185* (18); *8257, 11228, 11290* (11); *11390* (18); *11535* (11); *14375* (1b); *14848* (18); *16292* (1c); *16508* (8); *16592* (22b); *16787* (1c); *17294* (21); *17495* (8); *17893* (18); *17952, 21012* (21).
Yuncker, T. G. & W. H. Welch *10669* (7).

Zinck, N. H. *740* (7).

INDEX TO NAMES

Roman type indicates accepted, preëxisting names; *italics* indicates synonyms; bold face indicates new names or combinations.

Acanthothamnus aphyllus 285
Alsodeia glabra 231
Catha benthamii 244
monosperma 249
vitiensis 291
Ceanothus paniculatus 230
Celastrus 227
aculeatus 274
acuminatus 285
adenophylla 285
alatus 285
alpestris 285
angulatus 239
annamensis 244
aphyllus 285
apoensis 246
approximata 250
aquifolius 285
articulata
var. *cuneata* 261
var. *orbiculata* 261
articulatus 260
var. *pubescens* 261
var. *papillosus* 261
var. *punctatus* 266
var. *stephanotiifolia* 261
attenuatus 285
australis 236
axillaris 250
benthamii 244
bilocularis 285
bivalvis 285
boaria 285
bodinieri 285
bullatus 240
buxifolia 285
cantonensis 249
caseariifolius 282
cavaleriei 265, 286
championii 244, 246
chiapensis 282
chungii 286
ciliidens 276
circumcissus 286
colombianus 280
clemacanthus 276
confertus 286
crassifolia 273
crenatus 286
crenulatus 286
crispulus 266
cuneifolius 286
cunninghamii 286
var. *parviflora* 286
dependens 231
dilatatus 286
discolor 285
disperma 286
diversifolia 286
dubia 286
elevativenus 267
emarginatus 286
esquirolianus 286
esquirolii 287
euonymoidea 287
euphlebiphyllus 231
fasciculatus 287
feddei 287
finlaysonianus 287
flagellaris 276
floribundus 287
fournieri 287
geminiflorus 267
gemmata 258
gemmatus 258
glaucophyllus 253
glaucus 287
gracillimus 267
grenadensis 285
haenkea 287
hamelii 287
heterophyllus 287
heyneana 287
hindsii 249
var. *henryi* 249
hirsutus 270
hookeri 254
hookeri 274
hypoglaucus 257
hypoleucus 257
f. β. *argutior* 257
f. α. *genuina* 257
f. γ. *puberula* 273
ilicifolius 287
insularis 261
japonicus 287
jebolensis 261
jodinii 287
kiusianus 266
kouytchensis 287
kusanoi 268
lancifolia 261
laotica 231

latifolius 239
leiocarpus 267
lenticellatus 278
leptopus 287
liebmannii 279
linearis var. *madagascariensis* 287
lineatus 287
listeri 288
loeseneri 265
lokchongensis 258
longe-racemosus 267
longipes 281
lucida 291
lucida 288
lycioides 288
lyi 288
macrocarpus 288
madagascariensis 238
magellanicus 288
mainsiana 279
mairei 288
malayensis 246
marianensis 250
mauritiana 288
maytenus 288
membranifolius 255
meridensis 284
merrillii 250
metzianus 230
mexicanus 288
micrantha 288
microcarpus 285
mollis 288
monosperma 249
monospermoides 246
monospermus 244
montana 288
moya 288
muelleri 288
multiflorus 231
myrtifolius 288
neglecta 272, 288
nepalensis 288
novoguineensis 234
nutans 229
oblanceifolia 274
oblongifolius 250
obtusatus 288
obtusifolia 288
octogonus 288
opposita 289
orbicularis 289
orbiculata
f. *maior* 261
f. *microphylla* 261
var. *aureo-arillata* 261
orbiculatus 260
orbiculatus 253
f. *papillosus* 261
var. *papillosus* 261
var. *pilosus* 261
var. *punctatus* 266
orixa 289
ovalifolius 289
ovatus 289
oxyphyllus 289
pachyrachis 279
pallidus 289
panamensis 280
paniculatus 229
var. *andamanica* 230
var. *Balansae* 236
ssp. **multiflorus** (Roxb.) Ding Hou 231
ssp. paniculatus 229
ssp. **serratus** (Blanco) Ding Hou 231
var. *pubescens* 230
papuana 236
parviflorus 289
parvifolius 289
pauciflora 289
pentagyna 289
polybotrys 231
pringlei 281
pubescens 230
punctatus 266
punctatus 261
var. *microphyllus* 267
punctulatus 266
quadrangulatus 289
racemosus 279
var. trinitensis 285
racemulosus 249
repandus 285
reticulatus 285
retusa 289
rhombifolius 289
richardi 289
γ. *latifolius* 289
δ. *cochlearifolius* 289
ε. *elaeodendroides* 289
richii 237
rigida 289
robustus 289
rosthornianus 265
rothiana 229
rothianus 290
royleanus 290
rufa 290
rugosus 253
salicifolia 290
scandens 240
scandens 266
seguini 290
semiarillata 290

sepiarius 290
serrulatus 290
siltepecanus 282
spicatus 290
spiciformis 256
var. *laevis* 256
spinifolius 290
spinosus 290
stephanotiifolius 261
striatus 266, 290
strigillosus 261
stylosa 254, 265
var. *Loeseneri* 254
stylosus
ssp. stylosus 272
ssp. glaber 273
suaveolens 290
subspicatus 236
tatarinowii 260
tetramerus 290
tristis 290
uncinatus 290
vanioti 256
variabilis 290
venulosus 249
versicolor 261
verticillatus 290
verticillata 290
vitiensis 291
vulcanicolus 282
wallichianus 291
wallichii 291
wightianus 291
yunnanensis 291
zeylanica 291
Chailletia gelonioides 285
Colubrina ferruginosa 289
Diosma serrata 231
Elaeodendron glaucum 287
Embelia esquirolii 258
Erythrospermum hypoleucum 257
Euonymoides 227
scandens 240
Euonymus
altus 290
cuneifolius 286
euphlebiphyllus 231
thunbergianus 285
Flueggea serrata 249
Gouania corylifolia 290
Grewia
feddei 287
henryi 287
Gymnosporia
acuminata 289
crenata 286
diversifolia 286
emarginata 286
heyneana 287
montana 286, 288, 289
neglecta 285, 288
neglecta 272
ovata 289
rothiana 290
royleana 290
rufa 290
trigyna 288
variabilis 290
vitiensis 286, 291
wallichiana 286, 289, 291
Ilex
crenata 285
cuneifolia 287
macrocarpa 290
purpurea 285
scandens 286
suaveolens 290
Iodina rhombifolia 289
Kurrimia sp. 289
Maytenus
bilocularis 285
boaria 285, 288, 290
buxifolius 289
cochlearifolius 289
confertus 286
cunninghamii 286
dispermus 286
elaeodendroides 289
fournieri 287
lineatus 287
macrocarpus 288
magellanicus 288
meridensis 284
orbicularis 286, 288, 289
ovata 289
quadrangulatus 289
racemosus 279
retusa 286, 289
truncatus 287
verticillatus 290
williamsii 282
Microtropis bivalvis 285
Moya spinosa 288
Myrsine semiserrata 286, 290
Orixa japonica 286, 287, 289
Perrottetia alpestris 285
Phyllanthus sp. 290
Pittosporum floribundum 288, 290
Pleurostylia cochinchinensis 289, 291
Prema parvilimba 291
Prunus myrtifolia 288
Rhamnus
crenatus 286, 287
esquirolii 288
napalensis 290
racemosus 287
Sabia
parviflora var. nitidissima 287

yunnanensis 288
Saurauja vaniota 256
Schoepfia flexuosa 287
Scutia commersonii 291
Scutia (?) paniculata 230
Semarilla 227
Sempervirentes 242
Simmondsia californica 288
Trichilia jodinii 287
Tripterygium wilfordii 286
Wimmeria mexicana 288

MISSOURI BOTANICAL GARDEN

STAFF

Emeritus Director
George T. Moore

Director
Edgar Anderson

Assistant Director
Hugh C. Cutler

Carroll W. Dodge,
Mycologist

Robert E. Woodson, Jr.,
Senior Taxonomist

Henry N. Andrews,
Paleobotanist

Rolla M. Tryon,
Assistant Curator of the Herbarium

Hugh C. Cutler,
Curator Museum of Economic Plants

George B. Van Schaack,
Acting Curator of Herbarium

Julian A. Steyermark,
Honorary Research Associate

Frederick G. Meyer,
Dendrologist

Alice F. Tryon,
Research Associate

John D. Dwyer,
Research Associate

Nell C. Horner,
Librarian and Editor of Publications

Gerald Ulrici
Business Manager

BOARD OF TRUSTEES

President
John S. Lehmann

Vice-President
Daniel K. Catlin

Second Vice-President
Eugene Pettus

Leicester B. Faust
Dudley French
Henry Hitchcock
Richard J. Lockwood
Henry B. Pflager
A. Wessel Shapleigh
Robert Brookings Smith

EX-OFFICIO MEMBERS

Arthur C. Lichtenberger,
Bishop of the Diocese of Missouri

James F. Morrell,
President of the Board of Education of St. Louis

Stratford Lee Morton,
President of the Academy of Science of St. Louis

Ethan A. H. Shepley,
Chancellor of Washington University

Raymond R. Tucker,
Mayor of the City of St. Louis

Gerald Ulrici, *Secretary*

Volume XLII

Number 4

Annals
of the
Missouri Botanical Garden

NOVEMBER, 1955

The Food of a Hindu Village of North India
(*Reprinted from Bulletin No. 2, Bureau Statistics and Economic Research, United Provinces, Allahabad, 1937*) . . . . Charlotte Viall Wiser, Ph.B., M.Sc. 303–412

General Index to Volume XLII 413–418

PUBLISHED QUARTERLY AT GALESBURG, ILLINOIS
BY THE BOARD OF TRUSTEES OF THE MISSOURI BOTANICAL GARDEN
ST. LOUIS, MISSOURI

Entered as second-class matter at the post-office at Galesburg, Illinois, under the Act of March 3, 1879.

Annals
of the
Missouri Botanical Garden

A Quarterly Journal containing Scientific Contributions from the Missouri Botanical Garden and the Henry Shaw School of Botany of Washington University in affiliation with the Missouri Botancal Garden.

Informaton

The ANNALS OF THE MISSOURI BOTANICAL GARDEN appears four times during the calendar year: February, May, September, and November. Four numbers constitute a volume.

Subscription Price .... $10.00 per volume
Single Numbers .... 2.50 each

Contents of previous issues of the ANNALS OF THE MISSOURI BOTANICAL GARDEN are listed in the Agricultural Index, published by the H. W. Wilson Company.

Annals of the Missouri Botanical Garden

Vol. 42 NOVEMBER, 1955 No. 4

"THE FOODS OF AN INDIAN VILLAGE OF NORTH INDIA"

By CHARLOTTE VIALL WISER

[Mrs. Wiser's monograph originally appeared as Bulletin No. 2 of the Bureau of Statistics and Economic Research of the United Provinces, published in Allahabad, U. P., India, in 1937. It was based on data gathered by Mrs. Wiser and her husband, a distinguished sociologist, when they lived in the village of Karimpur at long intervals between 1925 and 1931. She eventually worked it up as a master's thesis in the Department of Foods and Nutrition of Cornell University, Ithaca, New York. Since copies of it are now almost impossible to obtain, either in India or the United States, we have obtained permission to reprint it from Mrs. Wiser, from the provincial authorities, and from Cornell University.

A single copy of it loaned to the Library of the Missouri Botanical Garden has been out-of-town on loan during a good part of the time since it was received. As an accurate, detailed, and perceptive account of what plants were grown for which purposes in a North Indian village, it is on its way to becoming a classic in the field of Ethno-botany.—E. Anderson.]

As an aid to bibliographers the original title-pages are here cited in full. Throughout the paper a determined effort has been made to reproduce the text exactly, even to the variant spelling. Nothing has been changed from the original copy except the references to page numbers.

The half-title is as follows:

BULLETIN NO. 2

THE

FOODS OF A HINDU VILLAGE

OF

NORTH INDIA

The title-page bears the following:

Bureau of Statistics and Economic Research, United Provinces

THE

FOODS OF A HINDU VILLAGE

OF

NORTH INDIA

BY

CHARLOTTE VIALL WISER, Ph.B., M.Sc.,

July, 1936

ALLAHABAD:

Superintendent, Printing and Stationery, United Provinces

1937

TABLE OF CONTENTS

	Page
INTRODUCTION . .	303
I—DESCRIPTION OF THE VILLAGE OF KARIMPUR AND ITS PEOPLE . .	304
II—FOOD SOURCES . .	308
A—VARIETY OF FOODS MADE POSSIBLE BY CLIMATE AND SOIL . .	309
B—THE CROPS . .	312
(1) CEREALS . .	313
(2) PULSES OR LEGUMES . .	313
(3) VEGETABLES . .	315
(4) FRUITS . .	316
C—ANIMAL PRODUCTS . .	318
D—SPICES . .	319
E—FOOD COSTS IN KARIMPUR . .	320
III—FROM FIELD TO SERVING TRAY . .	322
A—CARE OF FOODS AT HARVEST TIME . .	322
B—STORAGE AND PRESERVATION OF FOODS . .	323
C—EQUIPMENT . .	324
D—DISHES PREPARED FROM . .	330
(1) CEREALS . .	330
(2) PULSES . .	333
(3) VEGETABLES . .	336
(4) "GREENS" . .	341
(5) FRUITS . .	341
(6) ANIMAL PRODUCTS . .	344
E—FESTIVAL DISHES . .	346
IV—FOOD PRACTICES . .	349
A—TABOOS . .	349
B—NUTRITION PRACTICES . .	356
V—VALUE OF FOODS NOW IN USE . .	362
A—JAIL DIETARIES OF THE PROVINCE . .	363
B—THE WORK OF McCARRISON . .	365
C—FOODS AVAILABLE IN KARIMPUR . .	370
D—A STUDY OF DIETARIES OF FOUR KARIMPUR FAMILIES . .	379
VI—CONCLUSION . .	403
A—RECOMMENDATIONS . .	403
B—THE PROBLEM (SUMMARY) . .	408

I—INTRODUCTION

We moved to the village of Karimpur in the autumn of 1925. My husband and I had found during our years in India that if we were to understand the people of the villages, we must not be content to visit them, but we must live among them. After a study of the villages in the district, we chose Karimpur for our village home. Uninvited, we moved our tents and belongings into a mango grove on the edge of the village. In our ignorance we thought that our village neighbours would be glad to see us. But they showed no inclination to welcome white strangers, and were decidedly aloof until we had proven ourselves harmless. When they did finally accept us, they took our residence among them seriously, and saw no reason why we should ever leave.

We thought, in the beginning, that a few months would give us what we ought to know of custom, activity, and thought. But when the hot season of 1926 arrived and we were obliged to retreat to a bungalow in the town of Mainpuri, five miles away, we had just begun to appreciate our ignorance. We commuted to the village from the town during the summer, and returned to live in it as soon as the heat was bearable in tents. We repeated this migration annually until the spring of 1931, when we left for America.

My intention was that I should act as the good will of the study. With one son five, and another not yet two, I felt that I had all that I could undertake. But the village women, confined to their courtyards, could not come to me. They kept calling me to them. And as I saw more of them and their share in family activities, I realized that to understand and interpret the life of the village, we must know more about the women. They are of much more importance, economically, than most students of Indian villages have given them credit for being. Observations in this field led me into further interest in their share in the care and preparation of foods.

Meanwhile, the increasing number of calls on us for medical help impressed on us the futility of trying to cure ills while the causes of those ills went unquestioned. This led me into a study of village food from the point of view of health. I knew very little about food. But I had to acknowledge that if I wanted to understand and help Indian village women I must learn more about food, particularly their food. And out of this need grew the present study.

I learned all that I could about the foods procurable and the foods used, of food preparation and food customs. This material I carried to America, and with the help of specialists in the fields of nutrition and biological chemistry, I attempted to evaluate the foods eaten in our village, and to study the effect of customary methods of preparation on food values. The work was supervised by Miss Helen Monsch, head of the Department of Foods and Nutrition at Cornell University.

Miss Monsch and other members of the staff, especially Miss Mary Henry and Miss Marion Pfund, helped in the study of the chemistry of foods, and in securing standard tables of food values. Others who made the work possible were Dr. J. B. Sumner, Professor of Biological Chemistry, and Dr. L. A. Maynard and Dr. C. M. McCay, both of whom have much to bring to the field of human nutrition from their researches in animal nutrition.

I—A DESCRIPTION OF KARIMPUR AND ITS PEOPLE

Karimpur, the village of our study, is in the northern part of India, in the much fought over Ganges plain. This section of the country is known, under British rule, as the United Provinces of Agra and Oudh. The latitude of Karimpur is 27° 9″ North, about that of Palm Beach, Florida. The climate, however, is more continental than that of Palm Beach, and might better be compared with the same latitude in Mexico. The winters are delightful. In October, the heat relaxes, and the weather is progressively cooler until January when the mean temperature is 48.7° F. For us these are the months of refreshment. But for village families with lives regulated for hot seasons and no provision for cold, January and February are months of misery. In March the hot winds begin to blow, and from then until June the temperature rises steadily to a mean maximum of 112° F. The rainy season begins in July: over 60 per cent of the annual rainfall comes in July and August. The temperature drops only slightly but the rain brings relief to men and fields. September, at the end of the rains, with its heat and humidity, unrelieved by rain, is the most trying month for all of us. It is made endurable by the thought that the siege of heat cannot last much longer.

Karimpur is in an area which has played an important part in the history of India. Not far away are Kanauj, capital of the Harsha dynasty (A.D. 604), and Kampiyala, the stronghold of the Panchalas, heroes of the Indian epic, Mahabharata (before 400 B.C.). Sixty-five miles to the south-west is Agra, with its Taj Mahal, and great fort of the Moghuls.

Agra is the nearest city. Cawnpore, next nearest, is 110 miles south. As yet, neither city has made its influence felt in Karimpur. There are two market towns which link the village with the outside world. One is Kuraoli, 7½ miles to the north, with a population of 4,717. The other is Mainpuri, 5½ miles south. The population of Mainpuri is 15,599. Farmers of Karimpur take their surplus produce to either of these market towns to sell, and while on such an expedition, they may stop to buy clothing or food not available in the village. But they fear the clever merchants of the town, and avoid dealing with them as far as possible. They prefer to confine their activities to the village, with the minimum of outside contacts. Mainpuri is the official headquarters of the district. This necessitates trips to the Mainpuri courts to settle major disputes, chiefly those over land. But such trips are costly and confusing to farmers. And they prefer, if possible, to settle their disagreements at home with the advice of their own village council.

This aloofness has protected the Hindu culture of Karimpur from inroads of changing dynasties—an important reason why it is a good field for our study of Hindu foods. It shares this advantage with other villages of the district. But it has additional points in its favour. Mainpuri District covers 1,675 square miles and includes 1,388 inhabited towns and villages. Two hundred and five of these have a populaton of over 1,000, and are too large to be representative. Of the 1,183 under 1,000, many are very small and confined to few castes, and often to only one or two industries. Karimpur, with its population of 754, presents a variety of castes (seventeen), as well as two groups or castes of outcastes, four groups of Muhammadans, and several families of Christians. It is dominated by Brahmans, which strengthens its barriers against foreign ideas. Like most of North India, farming is its outstanding occupation, with the subsidiary industries needed in a self-supporting community.

The dusty, mango-shaded highway from Mainpuri to Karimpur, winds northward through a patchwork of small, oddly shaped farm plots separated from one another by low mounds of earth or narrow irrigation ditches. Sometimes there is an open stretch of uncultivated land which is too alkaline for crops, but which puts forth a stubby growth sufficient for meagre grazing. The animals must keep moving and searching if they are to keep alive. One is impressed by the leanness of the cows, and the thinness of the small boys who herd them. There are no houses on the farm plots. But there are hamlets, not much more than a mile apart, where the houses of farmers are huddled together. They are at a distance from the highway and easily passed unnoticed, with their monotonous gray walls.

If one were to follow this highway a few miles further north, he would come to the old Grand Trunk Road travelled by Kipling's Kim. Five and a half miles out from Mainpuri is the village of Karimpur. There are two small sections of the village directly on the highway, while the village proper stands back 200 yards to the east.

The first of the roadside sections is Chamar Nagariya, home of leather-workers. The leather-workers are counted as outcastes, but not as untouchables. All of the leather-workers' families save one, live in this section. It consists of just two enclosures side by side, with a high mud wall extending across the front of both of them. Along two sides of each enclosure are small rooms, one room to a family. The men who live here wear scant loin wrappings, and no shirt except in cold weather. They are dark-skinned. Their legs are long and spindling, and their knees and ankles bulge conspicuously. Their ribs and shoulder blades stand out, and their arms seem disproportionately long, like their legs. Their faces are deeply lined. Their teeth are ground down, and dark. The women's bodies are covered by long skirts, badly torn, but still so full that they are a protection. Over their heads they wear stained, grayish scarves, and some have short vests. One or two have smoother lines than the men, but the others have the same long thin arms and hard, bony hands. The boys and girls are dressed like their elders, and look like them except for their fuller faces, fewer wrinkles and better teeth. The babies are

plump and laughing. They go unclad when it is warm, and wear short vests when it is cold.

The other section by the roadside is Kachhi ka Nagla, hamlet of vegetable growers. They are true farmers by right of caste, along with the family of rice-growers which lives in the section with them. Although poor and in debt to Brahmans, they are independent, which may account for their living apart from the rest of the village. Among them we have the nearest approach to the joint-family that we find in the village. High mud walls enclose each joint-family, with its animals, its implements and its stores of grain—all of its possessions except land. The men, dressed in loin cloths, are short and slight but not as gaunt as the leather-workers. Their dark skin fits more smoothly over bone and muscle. One of their elders might be mistaken for Gandhi, especially since a cataract operation has made it necessary for him to wear spectacles. The women are small and thin, and their babies are plump and placid. The older children are copies of their parents.

As one turns east and bumps over the remnants of irrigation ditches which cut across the dirt road, to the village proper, he sees a long line of almost unbroken mud walls. He can guess where one man's wall ends and his neighbor's begins, only by the differences in height and smoothness of different portions of the wall. At the north end and at the south of this long wall there is a cluster of small, low-walled enclosures, each cut off from contact with the main wall by a lane. These are occupied by two castes of outcastes. Those living on the southern end are mat-makers, who make their living as farmhands. Their wives serve as midwives. The men are small and most of them are as thin as the leather-workers. But the arms and shoulders of the young women curve smoothly. And their skirts do not hang from protruding hip bones, like the leather-worker women, but from plump hips and abdomens. The outcastes at the northern end are the village scavengers, and therefore untouchables. They have recently been baptized as Christians, but are still regarded as untouchables by the villagers. Here too, the men are thin, with three exceptions. The younger women are attractively smooth-skinned, while the middle-aged and older women look tired, and their dark skin is drawn tightly over broad cheek bones, and hangs loose and dry between sharp elbow and wrist. In this group of untouchables one finds the darkest skins, the flattest noses, and the broadest faces in the village—evidences of Dravidian heritage.

Between the two outcaste communities there extends the long line of walls of caste enclosures. And beyond these enclosures are more like them, with the same high walls and small doorways. As far as possible they are built side to side and back to back, the only break being an occasional narrow lane or footpath leading to enclosures deeper in the village. If one is a stranger, he may follow any of the footpaths through the village and see only high gray barriers and blank doorways leading to stables. The stable is the entry-way to every enclosure. But if he is a friend, he sees the family enclosures overflowing into the paths. Children, puppies and goats tumble under his feet. Carpenters and potters carry on their work in the lanes before their doorways. And serving women salam him as they pass by

with head scarves drawn down over their faces. No matter how good a friend he may be, he never enters an enclosure other than his own. If it is necessary for a carpenter to repair a door frame or a beam, a man of the house accompanies him inside and remains until the work is finished. Women of serving castes are obliged to leave their own homes to work, but those of higher castes are jealously hidden within high-walled courtyards behind high-walled stables.

The families of each caste live close together, preferably in adjoining enclosures. The Brahmans (188) occupy the whole eastern section of the village. They are of priest-class by birth, but in practice they are farmers. Below them in the caste scale, in the order of their rank, are: bards (15), accountants (6), goldsmiths (10), flower growers (17), vegetable growers (152), rice growers (6), carpenters (42), barbers (2), water bearers (83), shepherds (26), grain parchers (10), seamsters (21), potters (9), tradesmen (14), oil pressers (10). In addition there are the outastes—washermen (6), mat-makers (28), and leather-workers (29). There are also the Christian sweepers (35); and four groups of Muhammadans—faquirs or beggars (23), bangle sellers (10), cotton carders (9), and dancing girls (3). The numbers given include all members of each caste, not just the members who are actually engaged in the caste industry. All of these, caste and outcaste, serve the Brahman farmers, and at the same time are able to exchange services with each other.

It is comparatively easy to recognize a Brahman. Even the older men among them who are bowed and withered, retain the bearing and features which mark them as Brahmans. There are exceptions, but one is fairly safe in picking the tallest, straightest, most firm-limbed young men as Brahmans. Their skin is fairer and their features finer than those of lower castes. Their noses are high and narrow. The Brahman women, always kept safely in the courtyards of their family enclosures, work as hard as other women. But they too have the fair skin, the narrow noses and faces, the firm, smooth bodies which set them apart from others of the village. None of them is fat. We have known only one fat person in the village, a woman of carpenter caste. Her fat was diagnosed as a symptom of her diseased condition. Brahman babies seem no plumper than others, and when weaned, they pass through the same period of loss in weight and resistance as do low caste babies. But if they survive this precarious stage, they surpass other children in weight, height, and strength. Smallpox scars and inflamed eyes are less common among Brahmans than among other castes.

Passing down from the Brahmans, the next three castes compare with them favourably. The goldsmith brothers are the village wrestlers, and are fed and massaged with this in view. Below them there is a decline in the evidences of well-being. From appearances it would be impossible to ascertain to what caste a man, woman or child of the humbler levels belongs. Sometimes an individual family gives its children a little better care than others, but such families are not confined to any one caste. A few Muhammadans may be recognized because of their more hawk-like noses. And the Christians are set apart by the consciousness of their

untouchability and their broader Dravidian features. Aside from these differences, all are very much alike. One becomes so accustomed to signs of insufficient food and care that his attitude toward standards of living is apt to shift.

Most of the men and women of the lower castes are angular, with hollows where flesh should be smooth. Bodies go unbathed, in contrast to higher castes where pour-over baths are supposed to be a part of the day's routine. They sleep and work in the same garments, and change them once in two or three weeks, whenever the washerman collects them to wash in the village pond. He uses cold water, beats the clothes on a rock, and spreads them on the dusty ground to dry. After a few washings a garment takes on the shade of gray of the earth and mud walls. The men's hair is cut short, with one long lock at the top. The women and girls do not use combs, and their hair tangles and mats, and offers refuge to multitudes of lice. Smallpox scars and eye infections or disfigurement are so common as to excite no comment. Both men and women work to the limit of their strength, and are thankful if they can earn enough food to make it possible for them to perform the tasks required of them. They do not hope for more, except on festival days when Brahman housewives hand out bread or cakes to the women and children of families performing regular services for them. The boys who run about the village lanes, or herd cows or sheep are small, lithe, and active, ready for any sort of fun. The little girls are the same. But before they are ten, they retire demurely to the courtyards where they care for their baby brothers or cousins, and imitate their mothers. The life cycle of the women is briefer than ours. The girls mature earlier—at ten or eleven—, are married at twelve or thirteen, and go to live in their husband's homes when fourteen or fifteen. From this time on, they are treated as grown women, capable of carrying a full share of the heavy work of farm households. They begin bearing children in the next two or three years, and although they do not have many babies, there is a constant sex-strain on their bodies. All of their work is done sitting or squatting on the ground, which is less wearying than standing. In spite of this, almost every mature woman of the village complains of the dragging down of her body. While we, in our early thirties, are facing the choice between a career and rearing a family, they are ready to sit back and tell their daughters-in-law how to feed their babies. The Indian Year Book for 1931 gives the mean age of males as 24.8 and of females as 24.7, according to the 1921 census.

II—FOOD SOURCES

The families of Karimpur retain their customary aloofness in meeting the problem of food supply. They prefer to accept the limitations of their own immediate environment, rather than venture into strange markets. Salt and spices are brought in from the outside, and sold by the small tradesmen. And an occasional purchase is made on a grain selling trip, or on a visit to a religious fair. These purchases are confined to familiar products which are considered a treat because of their limited

season or supply within the village. Unfamiliar products have no charm. About 40 miles from us is a district reputed for its oranges. These oranges are sold cheaply in the Mainpuri market during two winter months. But they are not brought home to the village. On the other hand, bananas are familiar, because a few are grown in the village. And bananas are brought from Mainpuri, when the price is sufficiently low. Each year tomatoes are sold in increasing quantities in the Mainpuri bazaar, but in the village the tomato is still a strange fruit, of an undesirable colour, and the villagers regard it with suspicion. Their diet is thus largely determined by the boundaries of their own fields. And it rises and falls with good and lean years. If the rains are favourable, and there have been no hail storms or destructive winds or pests, everyone has enough to eat. The villagers have learned to count on one or two such years out of every five. If the rains fail, or come too late, the whole village cuts rations. If one particular crop is damaged, they get along without it until it is harvested the following year.

Their exclusiveness does not limit their diet as much as one might expect. There may not be a variation in foods in one single day or in a week. But over a period of months there is considerable variety. The villager accepts his changes in food with the changing seasons. He is thus better prepared to welcome each new crop as it comes than is the town man who has greater variety each day. Still further, although the town man seems to have a greater choice of foods in the bazaar than the villager has in his fields, the villager has discovered many edible things which vary his diet and which rarely find their way to the town.

A—VARIETY OF FOODS MADE POSSIBLE BY CLIMATE AND SOIL

One reason why a greater variety of foods can be produced from a limited area, in the United Provinces than in Bengal and further south, is the greater distinction between the seasons. We have our hot dry summers when land rests, followed by warm rains which make crops of warm climates, like rice and sugarcane, possible. The rains are followed by a long dry season, a part of which is much cooler than Bengal, and which permits the growing of cold weather crops, such as wheat. One can better appreciate the variety of foods in Karimpur, by comparing them with the diet of less favoured districts. In his study of the use of food-grains in India, Church (1) found that "There are many districts in India where rice forms not merely the chief food-stuff but three-fourths or even four-fifths of its total amount. In some places it even rises to seven-eighths or to fifteen-sixteenths of the whole quantity, as in Burdwan, Dinajpur, Maldah, Kuch Behar, Manbhum, and Darrang; other districts might be named in which it constitutes the only food staple."

Another factor which contributes to the variety of the foods of our village is the variety of soils. The soils of Karimpur are typical of those of village communities of the Ganges plain. The following division of the revenue village is given in the latest Settlement report. These reports are made every twenty or thirty years by government settlement officers.

---

(1) See References.

Revenue village of Karimpur

	Acres
Village sites	35
Covered with water	202
Otherwise barren	1,609
Culturable land	2,103
Miscellaneous land	144
	4,093

The 2,103 culturable acres are distributed as follows:

Type of land	Acres
Gauhan	39
Manjha wet	204
Manjha dry	18
Barha Dumat wet	554
Barha Dumat dry	242
Barha Bhur wet	518
Barha Bhur dry	160
Maiyar	68
Tarai	300
	2,103

"Gauhan" is the land immediately encircling the village. It is the best manured, and is rented at the highest rate. It may be any kind of soil, usually a loam, improved by constant manuring. Farmers prefer to grow maize, sugarcane, peas and potatoes on this soil, or on the next grade, which is listed as wet and dry "Manjha." "Manjha" is the same type of land as "gauhan," but it is the strip just outside the "gauhan," and therefore less manured and less desirable. Most of the vegetables are grown on one of these two soils, partly because of the improvement of the soil, and partly because vegetables require constant care and constant watering except during the rainy season. The outlying land is known as "barha." "Barha dumat" is a mixture of clay and sand in almost equal proportions. It is "generally of a rich brownish colour, adhesive without tenacity, briable [friable] without looseness, slippery and greasy when wet and with a soapy feeling when dry, and cutting like a cheese when ploughed wet." "Barha bhur" is outlying land which is "loose and sandy, and quite incapable of retaining moisture." (2)

The "dumat" will bear a large variety of crops, including wheat, barley, several varieties of millet, and pulses. Whereas the "bhur" is so sandy that crops which survive with the least irrigation are reserved for it. It is usually limited to spiked millet and coarse pulses. "Tarai" is the low lying land, which "includes all classes of natural soils from very heavy clays to loose sand." (3) In our area it is chiefly heavy clay.

On the "tarai," rice is usually grown, and sometimes water melons. In ordinary years it is swamped during the rainy season. "Maiyar" is "a stiff, unyielding clay of a dark colour, shrinking and cracking in dry weather into a network of

(2), (3) See References.

fissures, but expanding when moistened into a sticky clayey mass." (4). It can be made to produce some of the less desirable pulses, and millets, and perhaps rice.

Each farmer wants a share of the better land, and not too much of the poorer land. This has led to the partitioning of land into small, queerly shaped plots. A man may have as many as sixty or seventy plots scattered over the different kinds of soil in every direction from the village. R. Mukerjee writes of these scattered plots, "Various are the causes which tend to render a peasant's fields so widely scattered. In the village communities there was a deliberate attempt to distribute plots among the settlers in different soil areas so as to allot plots of different degrees of fertility to each . . . The Indian cultivator's farm tends to fly into fragments and grows steadily smaller and less regular. As the population increases, the holdings on account of the law of succession come to be unduly fragmented." And further on he refers to "the pepper pot distribution of holdings." (5)

The following table shows the proportions of each type of land included in the scattered plots of *J*, one of the largest land-holders of the village, and compares the proportions of his holdings with those of the same kinds of land of the whole village:

Percentage of each kind of land in Karimpur compared with percentage of same kind of land held by J, a Brahman

Kind of soil	Percentage in revenue village	Percentage in *J's* hereditary holding	Percentage in *J's* total holding
Gauhan	1.9	1.2	0.9
Manjha	10.6	15.3	15.1
Barha Dumat	37.8	47.9	46.2
Barha Bhur	32.2	22.3	21.0
Tarai	14.3	13.3	16.8
Maiyar	3.2	. .	. .
	100.0	100.0	100.0

"The hereditary holdings show the closest correlation because they conform more closely to the original division of land." (6)

With such an arrangement, each long-established family has a chance to raise a variety of crops, even though its acres are few. Poorer farmers, and those whose forefathers came in after the original division was made, may have little or none of the best land, and a larger share of undesirable land. But even they manage to get a variety of crops, by hard work and a resigned acceptance of inferior products as part of their inferior lot.

W. H. Moreland of the Civil Service discusses the management of farm land composed of scattered holdings, in his Agriculture of the United Provinces:

---

(4), (5), (6) See References.

"Now, considering the variety of soils and of possible crops, this looks like a very complicated problem, and it is fortunate that the individual cultivator has not to face it without some guidance. The question has been attacked by many generations of cultivators and their accumulated experience is to be found in the *custom of the country* which guides the individual on such questions as what crops can be safely grown on hot soils, what crops will repay irrigation, what is the best means of distributing manure over the holding, in what order should crops be grown, and so on. This custom of the country is not an infallible guide to the most profitable utilization of the holding; the best course may never have been tried or may have been discarded through some mischance, or changes in the level of prices or as in the demand for particular products may make some changes in the custom desirable; but it is usually a safe guide to making a living, and the ordinary cultivator is well advised in following it rather than applying his limited intellect to working out a solution afresh."

And further on, he describes the arrangement of crops as actually practised:

"To see how this custom works out in practice, we may take the case of a holding of the ordinary size, say 5 or 6 acres, containing different soils. There may be a field of high sandy land; it cannot be irrigated and it dries so quickly that it would be very risky to sow winter crops on it: this land will usually have a rainy season crop. But even in the rains it is not very productive, for it will suffer from either wet or drought: not very much will be spent on its tillage, and it will usually be sown with cheap crops such as bajra (small millet) and moth (a pulse) which do fairly well on such land at a small expenditure. There may be another field of heavy clay; this will be regularly sown in the rains with rice, the only crop for which it is really fitted, while if possible some cheap pulse will be sown with rough tillage after the rice has been gathered. The rest of the holding consists, we will suppose, of irrigable loam. One portion of it, however, is so low lying that it is always more or less flooded in the rains: this portion will probably be sown regularly with a winter crop, which may sometimes be wheat and sometimes a mixture of wheat or barley with gram or peas. The rest of the land is suitable for either season and will be divided between the two in such a way that tillage can be effected in the time available. Possibly the cultivator will do this in the following way: taking the field nearest his house he will apply his manure to it and sow maize, which will be followed by some winter crop: another field he will put under great millet, arhar and urd (two pulses), with some sesamum to supply his house with oil, and a border of hemp to give fibre for well-ropes, etc.: the remaining land will be left for the winter and after manuring, sown with wheat along with a border of linseed or some lines of rapeseed, to supply more oil. In this way the cultivator would get an early supply of food from his maize, say about the end of August or September: rice in September or October; juar, bajra, urd and moth (two millets and two pulses) in November: pigeon peas and whatever cheap winter crops he had sown in March and April, when he would also have his wheat ready to sell for the rent.

"This is the holding of a cultivator of no special skill: a better man would get in a field of sugarcane or opium, or would manage to save more manure and take two crops in a year off a larger area, but the general principles will be the same: to secure sufficient food, with preferably an early supply in the rains; to have something to sell; to have a good variety of crops; and to arrange so that there may be time to till for all with the single pair of cattle which is all that a holding of this size can support." (7)

B—THE CROPS

One of the farming customs of the Ganges plain is the mixing of crops. Products intended for sale are kept unmixed. At least the farmer tries to keep them unmixed. But he is so accustomed to mixtures, that if barley or pigeon peas get into the wheat he sees nothing objectionable in the mixture. It is when his product reaches the city market, particularly where foreigners buy, that he is accused of adulteration. In his study of "Food-Grains of India," Church remarks, "The value of Indian wheats in European markets is often much lowered by preventable impurities. Very frequently they contain other cereal grains, especially barley; gram and linseed some times occur in them." (8) And McCay in his study of jail dietaries in the United Provinces, writes, "The chemical analyses of wheat in use in the different jails show greater variation than any other of the

(7), (8) See References.

food materials. This is practically entirely due to the different degrees of contamination with other grains, most of the samples in ordinary use were of second class quality and contained a large proportion of foreign grains." (9)

Wheat grown for home use is almost always mixed with the poorer quality cereals. Its presence makes bread made of barley or millet more palatable. And as long as the grains will be cooked together, they may as well be grown together. The more common mixtures have names, according to the grains they contain, and the proportions of each. "Gojai" is a mixture of wheat and barley. "Tirra" is wheat, barley and gram in equal parts. "Bejhar" may be equal parts of barley and peas, or equal parts of barley, gram and peas. Within the village, the selling or loaning of mixed grains can be carried on satisfactorily with the help of these names.

There are several advantages to the Karimpur farmer in raising mixed crops. A mixed crop may serve as insurance. A crop, such as rice, which flourishes in heavy rains, may be planted with a coarse millet, which flourishes in dry weather. Then, if the ground is flooded there will be rice, and if there is very little rain the rice may be lost, but there will be a millet crop. Sometimes two crops are grown together to save land. Millet and the pigeon pea are such a combination. The millet grows up more rapidly and the pigeon pea grows more slowly, until the millet is cut. As soon as the millet is cut the pigeon pea grows more rapidly, and when harvested yields about two-thirds of what it would without the millet. And the farmer is one millet crop ahead. In some cases a creeping pulse is grown with taller crops, to retain as much of the moisture in the ground as possible. Or a deep-rooted plant may be grown with one with shallow spreading roots. The most common crop mixture is that of at least one pulse with a cereal. The farmer does not know about nitrogen but he and his forefathers have found that the soil is benefited by the presence of a pulse. They have also discovered that pulse alone is not a satisfactory food. The mixture of pulse and cereal is the happy solution in the field and on the brass eating tray. The following record of his own crops, given us by a village cultivator, reveals the extent of crop mixing, particularly with food crops:

The grain crops of the village are familiar to us of the West except in the use for which some of them are intended. We in the United States regard certain millets, such as sorghum vulgare, as fodder crops, but in Karimpur they are grown as a complete family food—first for the human members of the family, and secondly for the animal members. Moreland, in his Agriculture of the United Provinces, remarks: "in many parts the cultivator cannot spare any part of his land solely for fodder crops, but must grow crops which will feed himself and his family as well as his cattle."

To a Westerner, the pulses are less familiar than the cereals. The "arhar," or pigeon pea, is the most common. Its yellow flowers colour the village fields during the cold season. It is one of the hardiest of the field crops. The peas, dried and

---

(9) See References.

Crops grown by a Karimpur farmer

Crop	Grown with	Reason for mixing
Wheat	1. Barley, or . . 2. Barley and gram . .	1. Mixed food. 2. Mixed food.
Barley	1. Gram, or . . . . 2. Wheat	1. Good for soil, and 2. Mixed food.
Field peas	Alone, or with wheat . .	Mixed food, and good for soil.
Sarson (mustard) . .	1. Wheat, or . . . . 2. Barley	Both save ground.
Gram	1. Wheat . . . . 2. Wheat and barley . .	Both for mixed food.
Duan (mustard) . .	1. Wheat, or . . . . 2. Barley	Both save ground.
Potatoes	Alone.	
Sugarcane	1. Hemp, or . . . . 2. Castor plant on border.	Both, 1 and 2, save ground.
Water melons	Alone.	
Little millet	Cotton	Saves ground.
Great millet	1. Pigeon pea, mung, or urd. 2. Mustard	1. Mixed food. 2. Saves ground.
Spiked millet	1. Moth (pulse) or pigeon pea. 2. Mustard	1. Mixed food. 2. Saves ground.
Maize	Alone.	
Rice	Alone.	
Pigeon pea	1. Millet . . . 2. Cotton	1. Mixed food. 2. Saves ground.
Urd (pulse)	1. Millet . . . . 2. Cotton	1. Mixed food. 2. Saves ground.
Mung (pulse)	Millet	Mixed food.
Moth (pulse)	Spiked millet	Mixed food.
Ronsa (pulse)	1. Great millet . . 2. Spiked millet . .	Both, mixed food.
Cluster bean	1. Great millet . . 2. Spiked millet . .	Both, mixed food.
Sesamum	Cotton	Saves ground.

split, are used by everyone. "Urd" and "mung" are much alike and are usually classed together. They are the best liked of all the pulses. "Moth" is the least used. Some do not care for it, while others keep a small store of it on hand as a special food for invalids. These three, "urd," "mung" and "moth," are dried and split, like the pigeon pea. Bengal gram is one of the most welcome of the products of the spring harvest. In the fields, around the home fire-place, and at the grain-parchers, it supersedes all other parchable foods. Travellers carry it parched, often their sole food. In the Indian army it has been adopted as emergency rations. A few pulses, like the field pea and the cluster bean, can be used green for a short period. But as soon as the peas are ripe they are treated like the other pulses—split and dried. When split, this whole group of pulses is known as "dal," an important division of any family's diet.

Vegetable crops are traditionally in the hands of vegetable growers, Kachhis. The task of growing them is not so much an exclusive privilege as a laborious caste duty. We have been interested in the slight increase in vegetables grown by ordinary farmers during our years in the village. They have discovered that enough water spills over the edge of the big leather water bags to keep vegetables alive on a small patch of ground surrounding an irrigation well. Beyond this they have neither the patience nor the interest to struggle with vegetables, especially in the hot weather when it seems as though nothing green can possibly survive. They leave vegetable growing to the Kachhis. The vine crop is the largest vegetable crop in the village. It includes several kinds of cucumbers and melons which were new to us. Like other foreigners in India, we found the hot season made almost unbearable by the absence of fresh vegetables, until our Indian friends introduced us to several unattractive forms of cucumber, melon and gourd, and showed us how appetizing they could be made with the help of green mangoes and spices.

Tubers and roots are depended upon for winter vegetables. Potatoes are dug and used when very small, chiefly because the crop is in danger of being stolen, or of being destroyed by porcupines. Radishes and carrots, on the other hand, are allowed to grow very large. In his Agriculture of the United Provinces (p. 222), W. H. Moreland reports "Radishes are grown for their bulk, and may be anything up to a foot in length." Of carrots he writes, "The Indian carrot is different from that which is familiar to Europeans as a vegetable; the root is dark coloured and is coarse and flavourless." Beets and tomatoes are grown on a small scale in the vicinity of Mainpuri, but Karimpur conservatism bars them from its fields. The prejudice is chiefly against their colour which is that of blood. Onions are limited in their growing and use to the lower castes. In the Laws of Manu, V. 19, it is written "A twice-born man who knowingly eats murshrooms, a village pig, garlic, a village cock, onions or leeks, will become an outcaste."

There appear, in the village list of vegetables, foods which we overlook. Buds of certain trees are treated as vegetables. And a whole series of leaves, some wild and others incidental to the growing of some field crop, are utilized. Among the former is the white goose foot, and among the latter are radish tops, the leaves of

the Egyptian arum, and the tender tips of pulse and mustard plants. All of these leafy foods are set apart from other vegetable foods, and cooked in a special way. In the village they are called "sag," or greens.

The village looks to its trees as a special source of variety in the diet. And the trees have something to offer during most of the year. Some of the fruits, like the neem and peepal berries, we would never consider as human food, and in government publications they are listed as famine foods. But the children eat them in large quantities and farmers munch them on their way to or from the fields. The children also gather and eat the blossoms of the mahwa tree, and forage for wild plums. Their enjoyment of plums, as well as of other fruits, when hard and green, is amazing. Anyone who has tried to eat a tamarind pod knows how painfully sour it is. We use it to make a hot season drink. But the village youngsters chew one after another without a blink. The tamarind is valued in Sanskrit medicine for its antiscorbutic effect. Certain fruits are so rare that only a few can have them, even for a limited season. Among these are the pomegranate, custard apple, guava, date and lime. Bananas are somewhat less rare, but are treated as a luxury. They are sliced green, skin and all, and cooked with vegetables. Muskmelons and water-melons appear when most welcome, in the hot, dry weather. Everyone manages to get a share of both.

The most popular and the most abundant of all the fruits is the mango. In the hot months, when the ground is baked hard and few growing things survive, the mango trees yield their crop. Mangoes seldom ripen. Wind storms bring down some of the fruit. And the rest comes down, with the help of sticks and stones and secret trips up the trees, before we think it ready to eat. It is the right of everyone in the village to have a share of the mangoes. This is in accord with the Laws of Manu (VIII, 339). "The taking of roots and of fruit from trees. . . . Manu has declared (to be) no theft." The owners of groves do not object to the stripping of their trees, as long as the trees are not damaged, and as long as the fruit is reasonably distributed within the village without being sold. If mangoes were picked and sold, even by the owner of a grove, the village would deal with the offender by its own unique method, that of non-co-operation. We have known progressive landlords who have raised mangoes for sale, but they have been powerful enough to assert their rights. In our village, the old custom prevails to the extent that owners of groves entertain no thought of financial profit. One man, of farmer caste, owns an unfenced grove of 25 old trees, bearing in a good season over 50,000 mangoes Our office clerk lived in the home of this farmer, and was in a position to observe closely. No mangoes were brought into the owner's house from his own grove, during the clerk's two year's stay with him. Fruit from nearby trees, belonging to others, met the needs of his family. He was following the practice of his forefathers in letting others enjoy the fruit from his trees. And he is assured that as they were blessed by the religious merit thus acquired, so will he be blessed, especially since a number of those who eat his mangoes are twice-born. The Government encourages the preservation of groves by not taxing them as

long as they remain groves. Rule 4, Chapter I of the Wajib-ul-arz (Customary Law) states that, "If the trees of a garden are cut down and new trees are not replaced, the Government will have a right to assess land revenue according to circle rates, if that grove has been exempted from the assessment of land revenue at the time of the current settlement." This has helped retain the groves which existed before the last settlement. But there has been almost no effort to plant new groves. The custom of free distribution of fruit fitted into the old regime of simple, personal exchange. Under the comparatively recent system of money exchange, men want some assurance of a money return, before taking the trouble to plant and foster young trees. The following table gives a picture of the sources of the village supply of cultivated fruits.

Number and kinds of trees found in groves of Karimpur

Name of tree	Number mature trees	Number immature
Mango	159	187
Tamarind	1	4
Neem	219	1,051
Peepul	12	8
Gular (wild fig)	5	37
Bel	36	66
Wood-apple	5	27
Indan jujube	46	132
Jaman (kind of plum)	45	63
Khajur (kind of date)	9	76
Khata labhera (plum)	24	55
Heens	..	17
Jack fruit	..	9
Chuara (kind of date)	..	9
Pomegranate	5	2
Guava	50	25
Plantain	18	..
Lime	3	5
Mahua	12	3
Rai labhera (kind of plum)	..	1
Banyan	1	2

Number and kind of trees on the village site

Name of tree	Number
Mango	1
Tamarind	10
Peepul	3
Ber (Indian jujube)	8
Jaman	3
Khata labhera (plum)	2
Anar (pomegranate)	1
Amrud (guava)	2
Banyan	3
Bel	1

The ponds near the village contribute a share of the food supply. Vegetable growers and water-bearers collect generous quantities of water chestnuts and seeds of phapola, a water vine, from nearby ponds, and sell or exchange them at such a low rate that everyone can buy. The phapola, puffed, or popped, was one of our happiest discoveries among village foods. We like it better than popped corn.

At the festival known as Deotan, in November, everyone in the village is allowed a taste of sugarcane, even though it is not ready for cutting. From this time on, one meets children and men chewing and sucking stalks of cane. A stalk may be broken off as one passes by a field, without offence. Not much fresh cane reaches the women shut in the courtyards. But they enjoy whatever the children remember to bring home to them. The fresh juice adds variety to a number of dishes during the pressing season. And the raw sugar, made by boiling down the juice and pressing it down into large cakes, supplies the village with sweetening for the year.

C—ANIMAL PRODUCTS

Animals are a minor source of food supply in a vegetarian community like Karimpur. Cows are kept and milked, but the milk is seldom used as such. Boiled, churned into butter, and clarified, it supplies the pure fat for deep fried foods. Beef is never eaten. Goat meat is eaten about twice a month by the goldsmiths. And Muhammadans eat it oftener, if they can afford it. The goats kept by the village goatherds are supposedly kept for milk, which is sold in Mainpuri. But occasionally a goat, no longer useful, is sold quietly to a Muhammadan butcher. Any goat meat beyond this comes from Muhammadan communities outside Karimpur.

Fish is not eaten by members of the higher castes. But members of lower castes have a feast of fish, during the few days before the ponds dry up for the hot season. The men who are draining the pond with their reed water-lifting baskets, let it be known when the water is getting too low for further usefulness for irrigation. The word passes swiftly, and on the following morning a crowd of low caste men and children gathers at the edge of the pond. Each one has a big round basket without a bottom. The instant the irrigators announce that they are through, the fishers wade into the shallow water and push their baskets down into the mud bottom. They scoop out any fish they have thus captured, and move forward a few steps where they try again. The fish are small, but they are an annual treat.

The few chickens in the village belong to the sweepers, lowest of the outcastes. No one else would eat their eggs or their flesh. The sweepers, along with the Dhanuks, another group of outcastes, own the swine, which act as village sewage system, and which are the only animals raised with a view to butchering. There are many foods denied these outcaste families, but when a swine grows old or ill and is butchered, the feast is theirs. No caste person would come near enough to interfere.

If a family is small, and can afford to keep a buffalo, there will be "ghi" or clarified butter, for all of the cooking. But in most families the "ghi"* must be supplemented by mustard oil, or sesamum oil. There are several varieties of mustard and rape grown in the fields of Karimpur, usually mixed with grain crops, but harvested separately. Each farmer tries to have his own supply, which he

*Pronounced "ghee".

stores, and has pressed month by month, by the oil presser. The better grades are very satisfactory for deep-fat frying. The poorer grades are bitter. The women who are obliged to use the poorer oil, try to relieve it by adding some of the better. When mustard oil becomes scarce, the sesamum harvest is ready with its fresh oil supply. The sesamum is valued not only for its oil but for its flavour. The seeds, with crude sugar, are made into balls. These are among the most popular sweets in the autumn.

D—SPICES

If one tries eating Indian vegetables with only salt added, and then visits an Indian home where these same vegetables are prepared with spices, he has a new appreciation of the art of spicing. An untempting vegetable can be spiced and cooked in several ways, and scarcely be recognized as coming from the same plant. This ability to use spices properly is even more important where there is no meat or meat stock to supply flavour. The variety of spices used in a village home is limited by purchasing power. Everyone tries to have at least red and black pepper, coriander, asafoetida, and turmeric, along with salt. Other spices are necessary for certain dishes, but may be omitted from ordinary daily cooking. A list of spices sold by a village tradesman follows. Two other tradesmen have smaller stocks of the same things. The list does not include peppermint, which is grown in some of the larger courtyards, or coriander, which is grown in fields with grain crops.

Condiments sold by Mohan Singh, Karimpur

Local name	English name	Botanical name*
Hing	Asafoetida	Ferula alliacea.
Lal mirch	Red pepper . .	Capsicum frutescens used both green and ripe.
Kali mirch. . . .	Black pepper . .	Piper nigrum. From unsorted berries, with some husks.
Safed mirch . .	White pepper . .	Piper nigrum. From sorted berries.
Saunf	Aniseed	Pimpinella anisum.
Kala jira	Small fennel . .	Nigella sativa.
Safed jira	Caraway	Corum carui.
Haldi	Turmeric	Curcuma longa.
Laung	Clove	Eugenia caryophyllata.
Chhoti elachi . .	Small cardamom . .	Ellettaria cardamom, true cardamom.
Bari elachi	Greater cardamom . .	Amomum subulatum.
Nariyal	Cocoanut	Cocos nucifera.
Ajwain	. .	Caryota copticum.
Sonth	Green ginger root . .	Zingiber officinale.
Kismis	Raisins	Vintis vinifera
Chiraunji	. .	Buchanania latifolia.
Namak	Salt	. .
Kala namak . .	Common salt with sodium carbonate, in sort of fusion.	
Chhoti pipar and bari pipar.	Long as cloves, but thin. Not quite as hot as pepper.	
Har	As thick as cardamom, and a half inch long. Supposed to aid digestion.	

*As in the rest of the paper, the spelling is reproduced here exactly as in the original copy.

E—FOOD COSTS IN KARIMPUR

Food prices given in the accompanying table are rarely paid. Farmers would not have money to buy food at these rates, low as they seem to us. They produce most of their own food, or exchange food which they have stored, for food or services which others have to offer. When the exchange is made, there is a great deal of arguing, and he who is the best barterer gets the best bargain. Either the seller or the buyer produces balance scales. One article to be exchanged, such as cucumbers, is put into one pan, and barley, corn, rice or almost any food is placed in the other. The exchangers agree on how the scales should hang, according to their estimate of the value of each article. The pan of cucumbers should swing far down if wheat is in the other pan. If there are sweet potatoes in the other pan, they should almost balance the cucumbers. With this in mind, one realizes the futility of measuring a farmer's food expenditure in terms of money. At best, it can only give a general idea of comparative values. The figures here given we believe to be as accurate as can be found. They were recorded by our clerk, in the household of farmer caste in which he lived. If we were to list the prices which we were actually paying for the same articles at the same time, our figures would be much higher—twice as high in some cases. A white face always sends prices up.

Prices of foods in Karimpur in 1928

Article	Number of pounds purchased for 1 rupee
Wheat	18
Barley	24
Maize	20
Rice	14
Spiked millet	16
Great millet	17
Gram	30
Urd	16
Mung	16
Moth	10
Pigeon pea	32
Milk	12
Ghi	1.25
Mustard oil	3
Potatoes	50
Lauka (kind of pumpkin)	50
Lauki (kind of gourd)	33
Turayan (kind of gourd)	43
Okra	27
Cauliflower	43
Egg plant	66
Green figs	33
Bitter melon	27
String beans	66
Radishes, with tops	66
Carrots	66
Egyptian arum	43
Khata labhera (blossoms)	25
Khata labhera (green fruit)	43
Cluster bean, with pods	65
Cow pea	65
Field pea	33

Article	Number of pounds purchased for 1 rupee
Onions	43
Cucumber	33
Sweet potatoes	33
Kacheria (kind of melon)	43
Senda (variety of cucumber)	43
Mushroom	43
Mustard tops	65
Fenugreek (green)	43
White goose foot	66
Gram tops	65
Spinach and dill	43
Nori (wild pot-herb)	66
Onion tops	99
Paintiya	66
Lissua (wild pot-herb)	66
Pea vine tops	66
Chaunrai (pot herb)	99
Leaves of Egyptian arum	16
Mangoes	66
Guavas	21
Jaman (kind of plum)	66
Water melon	43
Ber (Indian jujube)	66
Water chestnut	66
Tamarind pods	27
Musk melon	43
Raw sugar	12
Salt	28
Red pepper	3
Black pepper	1
Turmeric	2
Aniseed	5
Coriander	3
Asafoetida	0.2
Cloves	1
Big cardamom	1
Garlic	8
Fenugreek (seeds)	8
Caraway	2

Price of meat

A two-year-old pig, weighing about 75 pounds, was butchered on 10th February, 1928. It was divided into 12 shares plus the head. Each share weighed about 5½ pounds, and cost about \$.16. The head weighed more, and was the most desirable part. Cost \$.20.

III—FROM FIELD TO SERVING TRAY

A—THE CARE OF FOODS AT HARVEST TIME

At harvest time, all of the able bodied men and boys of the village and some of the low caste women go out to the fields. Some cut their own crops, and some are employed to cut those of others. The men squat in a row at one end of a field and move slowly toward the opposite end, cutting the grain handful by handful with their sickles as they hunch along. They tie the cut stalks into bundles, binding them with tough grass. When a field is finished, they carry the bundles, usually on their heads, to one of the groves beside the village. We camped in one of these groves and used to watch the men coming in, balancing their loads and dropping them on the large pile belonging to the master of the field.

The millets are treated differently. Women of farmer and water-carrier castes walk slowly through the field breaking off the heads of grain and dropping them into large flat baskets which they carry. Later the men cut the stalks. This job can be postponed until more important crops are harvested.

Rice is cut in the usual way, but is not carried to a grove. It is threshed close beside the field where it has grown.

Most of the grains and pulses are threshed by the treading of bullocks on a threshing floor. The threshing floor is simply a circle of ground from which grass and weeds have been scraped. The threshing-floor for rice is prepared beside the rice field. Other threshing-floors are in the groves where the cereal and pulses have been stacked. In our grove there were five and sometimes six threshing-floors being used. On each of them from two to six bullocks were driven round and round day after day. Small boys usually do the driving. A stack of grain about three feet high, covering a threshing-floor with a radius of ten feet, takes three days to be threshed by four bullocks. This varies of course with the activity of the driver. People without bullocks must leave their grain stacked in the grove until some one else's animals are available.

In the threshing, the husks are loosened, and many, but not all, are separated from the kernel. The husks of rice and barley are not loosened, by the treading of bullocks. With these two the threshing simply breaks the kernels from the stalk. The actual husking has to be done later by the women in the courtyards.

Close after the threshing comes the winnowing. The men hold shallow baskets of grain high above their heads, and tilt and jerk them in such a way that the kernels fall to the ground. The chaff is carried away by the breeze. If there is no air stirring, two men stand behind the winnowers and flap a long sheet, thus making a breeze.

Grain to be sold is weighed out and poured into gunny bags, beside the threshing-floor. The two men who keep large store-houses of grain to loan or sell later in the season to village neighbours, measure their grain into sacks and have their hired helpers carry it to their store-houses. A few others keep their surplus in

bags. But most of the products of any harvest—grains, pulses, vegetables, or fruits—are carried home from threshing-floor, grove or field, and poured out on the floor of the courtyard. Whatever remains to be done, is the work of the women.

B—STORAGE AND PRESERVATION OF FOODS

The women shape tall jars of clay which remind one of the tale of Ali Baba. They must have them made and well dried before the harvest. As rapidly as the grain is brought in, they spread it on sheets, on their roped cots, and keep moving the cots so that they may get all of the sun possible within the courtyard. When the grain is thus thoroughly dried, they clean it basket by basket full, and fill the jars with it. Near the base of each jar is a small opening, plugged with rags. Through this, a day's supply of grain can be drawn out.

Pulses to be stored require additional treatment. The women must remove any pods not removed in threshing. Then they soak the pulse over night in water and oil. The quantity of water varies. To five pounds of pigeon peas they add ten pounds of water and three and a half ounces of oil. To five pounds of "mung", "urd", or "moth" they add only four ounces of water and an ounce of oil. After the soaking they dry the pulse in the sun for a day or a day and a half. For this they requisition every cot in the house and every sunny inch of the courtyard. When the pulse is thoroughly dried, they split it in the light stone hand mill described. If a woman does not own such a mill, she tries to borrow one from a neighbour or employer. If she cannot borrow, she pries apart the stones of her flour mill, with a wad of cotton on the top of the pivot, and splits the pulse in it. She may split her whole season's supply immediately after the harvest, or she may take care of enough for three or four months at a time. During the splitting process many husks are loosened. She gets rid of them by winnowing the pulse and sifting it, before storing it in clay jars.

There is heavy work left for the women, in the care of rice and barley. Both of these have been partially threshed by the treading of bullocks. Bullock's hoofs are able to separate the husks from the kernels of some grains, but not those of rice or barley. This task is left for the women. With an iron-bound wooden pestle, a woman husks her rice or her barley in a stone mortar set in her floor. It is tiring, strenuous work, and she prefers to do a small portion at a time, as it is needed.

Where there is a supply of a certain grain to be stored, too small to require a tall jar, it is stored in smaller jars, made and baked by the village potter. These are often found in rope baskets, suspended from beams of the family's store-room, off of the courtyard. Grain kept for seed may be stored in the same way, or hung in the courtyard on a beam protruding beyond the store-room wall, protected by eaves. The village housewife wages continuous battle with the rats and insects which covet her stores, and with the crows which settle on the courtyard wall waiting their chance to swoop down on drying grain.

Drying is not limited to cereals and pulses. Greens, such as the tips of peas and mustard plants, are chopped, and dried on the cots in the sun, and kept in baked clay jars, or in bags improvised from old skirts and shirts. "Mahua" flowers, if not all eaten fresh, are similarly dried. Coriander, the most used of spices, is gathered by the children and dried by their mothers. Mangoes, peeled and dried, are kept in jars to be used later to flavour insipid dishes. Mustard seed is dried and stored, ready to be doled out to the oil-presser when a fresh supply of oil is needed.

The only other forms of preservation within the reach of a village housewife are spicing, preserving in oil,, and preserving in salt. Vinegar is not used. The containers in each case are clay jars of various sizes, made by the village potter. Carrots and radishes will keep about a week, if well mixed with spices and covered with oil. The "rai labhera" (small plums) keep longer. And horse-radish, limes and mangoes keep for months. The "rai labhera" and limes are scarce, and hence available to only a few. They require a little oil, and spice. The horse-radish and mango are within every one's reach. Mangoes lend themselves to the greatest variety of preserves. In salt they are acceptable, in spices and oil they are a happy addition to a noon day meal, and in raw sugar they are a special treat.

With clay jars or old cloths as her only containers, and a stifling room as her only storing space, there it little more that the village woman can aspire to, in carrying foods beyond their season.

C—EQUIPMENT

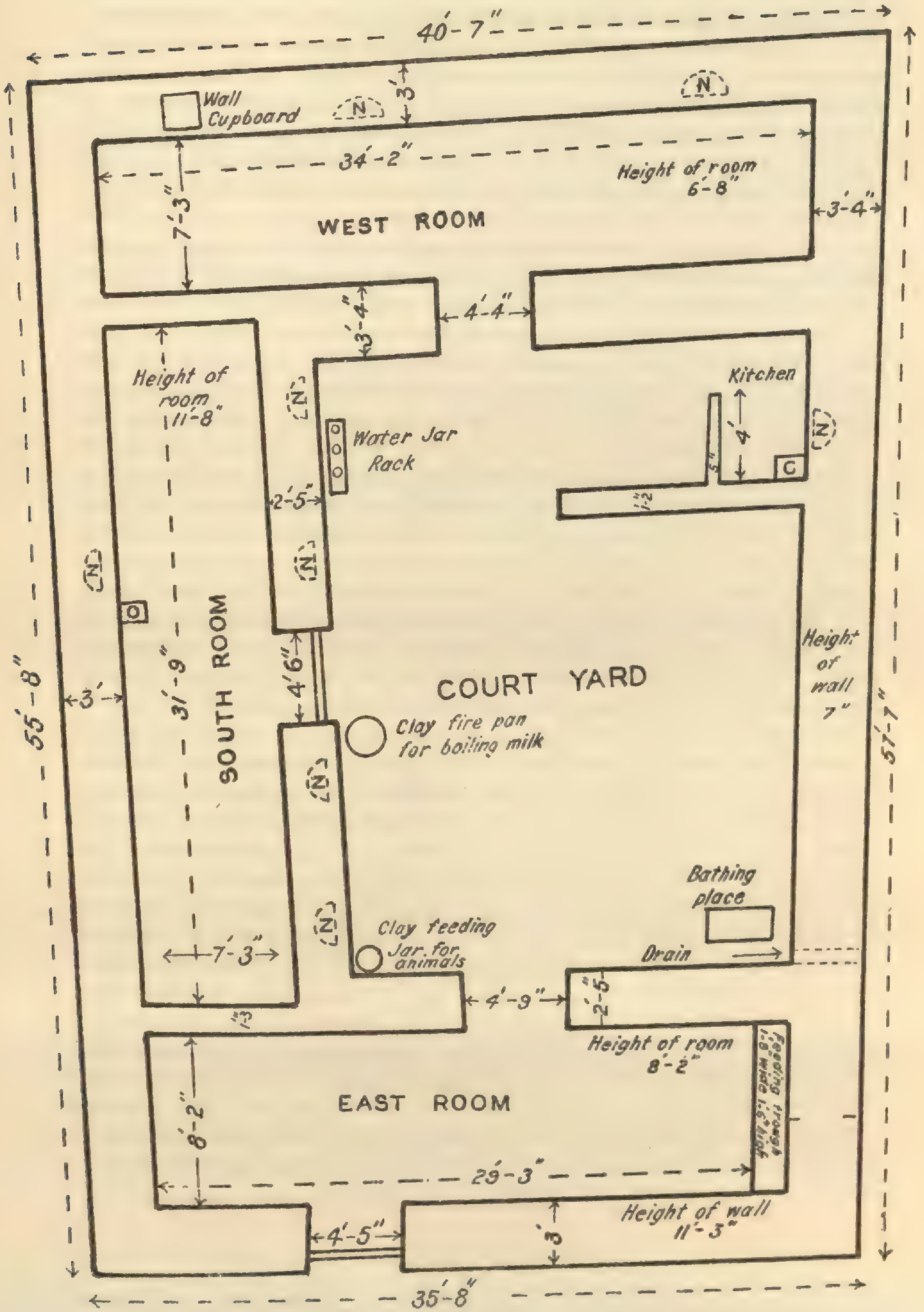
Before considering the further processes through which the food materials must go in the home, it will be necessary to study the equipment with which a village woman works. Her work-room is the courtyard in which all family activities are carried on. The earth is her floor, and the sky is her ceiling. From the courtyard she sees only these and the walls of mud around her.

The walls which surround her are made of mud dug from the bottom of a near-by pond. She cannot see over the tops of the walls and, more important still, no one can look over the walls at her. If she is a Brahman, her courtyard will be large enough for her to work in, and to spread out her grain comfortably, with plenty of sunshine most of the year, and at least a patch of it crossing the floor in mid-winter. If she is an outcaste, her courtyard will be small, originally high, but her walls will be eroded until low enough to admit abundant sun and air. The women who suffer are those whose courtyards are small, and whose husbands insist upon keeping them in strict seclusion. Such a one is the oil-presser's wife, whose courtyard is cramped, and high-walled. During the rains, she works in puddles, and during the winter she shivers between damp walls which shut out the sun. She and her children are among the most wretched in the village.

The carpenters are as near average as any group in the village; and a diagram of a carpenter's house is shown on opposite [page]. The enclosure is a typical in that it has two rooms off the courtyard. Usually only Brahmans have two, whereas those

GROUND PLAN OF A KARIMPUR ENCLOSURE

8 Feet = 1 Inch



less than Brahmans should be content with one. In this particular case the second room was added to accommodate extra brothers. It is now falling into disrepair.

The doors of the courtyard lead to store-room or cattle-room, not to the outside world. On rare occasions when a village woman is going to her father's home for a visit or to the wedding of a relative, she swathes herself in a coarse sheet and goes out through the cattle-room. Her only other means of exit is by ladder. If her courtyard has a ladder, she climbs to the top of her wall and looks over at her neighbour, and if no men are at home in her own or her neighbour's house, she drops down into her neighbour's courtyard for a hasty visit. Aside from these rare breaks, she spends her life in her own courtyard, with food-preparation as her chief task. Her children wear few garments, and these are made by the village seamster, and washed by the village washerman. She has no furniture to care for beyond the unvarnished roped cots, used as beds by night and as drying-racks by day.

During the winter weeks, coverings of home spun sheets or padded quilts are used. These she throws over wooden pegs projecting from the courtyard wall. She has no hangings or rugs, or silver or china to care for. If food processes were as simplified for her as they are for us, her life would be easy. But as it is, her work is heavy and slow.

Her activities centre around her "chulha" (fireplace). Generations ago a great-grandmother-in-law made it in a secluded corner of the courtyard and each daughter-in-law since has kept it in repair. There is a supplementary "chulha" in the store-room to be used in stormy weather, but the one in the courtyard is the true family hearth. It is made of mud piled up and shaped so as to protect a small flame and to support a cooking utensil. (The daily care which the housewife gives her "chulha" will be discussed in connexion with the ceremonies of cooking and eating.) Her fuel is the twigs which the children gather from groves, or the dung cakes which she and other women of the household have shaped.

Almost as necessary as her fireplace is her stone flour-mill. All the grains and pulses which are to be made into bread must be ground in the home mill. The mill is made of two stones, cut like discs about two inches thick and from one and one-half to two and one-half feet in diameter. The housewife has embedded the lower stone in a base of clay, which lifts it to a convenient height from the floor. The upper stone is free to turn on the lower one, being held in place by a peg in the centre of the lower stone which passes through a hole in the centre of the upper stone. The clay base has a diameter several inches greater than that of the stones, so that it forms a border around the outside of the mill. This is trenched to look like a moat surrounding a low stone castle. As the woman turns the upper stone round and round with a wooden peg fitted into a slot near the rim, she pours her grain into the hole at the centre of the stone. As the grain is crushed and ground between the stones it gradually spills out around the edges into the encircling moat. When the grinding is finished, the housewife brushes the flour out into a winnowing basket, and separates chaff and clay-dust from the ground grain. She returns some of the bran to the flour, unless the bread is intended for a special feast. The grinding is heavy, tedious work, and if possible two women share it, sitting facing

each other across the mill, each with a hand on the turning peg. One of them pours the grain into the centre hole, without breaking the rhythm of the turning. The steady hum of the grinding stone is one of the earliest morning sounds of the village. In a few homes one finds a "darenti", a mill patterned after the one described, but smaller and lighter. It is used in splitting the pulses. As the supply for several months can be food. For the winnowing and sifting there are baskets and sieves. Cooking utensils are never borrowed, but the "darenti" is regarded differently, although it touches the food.

Before rice or barley can be ground they must be husked. For this the housewife has a pestle and mortar. The pestle is a thick pole about four feet long, bound with iron rings, one of which forms a rim at the bottom. The mortar is a stone cup set into the earth floor of the courtyard. The husking is another strenuous task usually shared by two women. They sit on the floor one on either side of the mortar. Each woman holds a pestle, and turn by turn, each lifts her pestle above her head and brings it down heavily into the rice, some of which is struck, but much of which flies out of the mortar. One of the women keeps brushing the scattered grains back into the mortar, while managing to keep her hand out of the way of the pestles, and not missing her turn. The grain thus treated is not only husked but chipped and broken. However, skilful winnowing saves every scrap that might [be] food. For the winnowing and sifting there are baskets and sieves of several sizes and shapes. The winnowing baskets are of reeds. The sieves may be strung with coarse threads or reeds.

The utensils which the village housewife uses are made of brass, iron, stone, clay or wood. When she makes her daily bread (she actually does make it every day), she may mix and knead her dough in a bowl of brass or wood, or baked clay. She pats out the flat round cakes with her hands if the flour comes from mixtures of corn, barley, millets or pulses. If the cakes are of wheat, and especially if they are intended for guests, she rolls them out thin on her small round breadboard, which is of stone rather than wood if she can afford it. To bake her bread, she may rest over her fire a convex iron plate which she brushes with clay, to keep the cakes from sticking. Or she may fry the cakes in deep fat in an iron vessel shaped very much like those which we use for deep-fat frying. She lifts the cakes out of the fat with a long-handled, flat-bowled iron spoon, which may or may not be perforated. And when her bread is ready and her husband calls for it she serves it on a brass tray, always brightly polished. For cleaning her brass she rubs loose a bit of her earth floor, applies it with a knot of grass and much rubbing, and rinses it off.

When she prepares vegetables she rarely removes the skins, but cuts up the whole vegetable with a small sickle. She braces the handle under her toes so that the blade stands upright. Against this she pushes the vegetable. Greens are held in bundles and cut through in the same way. To fry her vegetable, she uses the same iron pan for deep-frying. To boil her "greens" (leaves and herbs), she uses a brass kettle with straight sides and no handles. Both "greens" and vegetables

she serves on the brass tray with the bread. The bread is broken off bit by bit and used to dip up the other food. If she is serving guests, she will place bread and vegetables and any other food on clay saucers or dishes made of large leaves bound together with twigs. These can be thrown away when the guests depart. In no case should household utensils or dishes be touched by others than members of the family. When I admire a piece of brass, I always admire from afar.

Every day the housewife grinds the spices to be used in the food. For this she has a stone about an inch thick, about six inches wide and a foot or more long, curving gracefully to a point at one end. On its corrugated surface she lays her spices, sprinkles them with water, then rolls a small, rough stone roller back and forth over them until they form a paste.

Every morning and evening she puts fresh milk on to simmer. For this she uses a baked clay jar, set in a smouldering fire of dung cakes. A separate fire-arrangement is required for this long period cooking. It consists of a large, shallow basin with a thick base which she has made of clay. In it she places a burning dung cake, with others arranged over and around it, like a nest for the jar of milk. After hours of simmering she pours the scalded milk from this clay jar into another kept for the purpose. And the next morning she pours the clabbered milk into still another clay jar which serves as a churn. Each of these jars has a distinct shape and is called by a different name. The churning paddle is a stick of wood with cross pieces at the bottom. The woman who is to churn loops a rope around the leg of a cot and then twists it at the middle around the paddle, and holds the two ends in her two hands. By pulling one end of the rope and then the other, she rotates the paddle horizontally and keeps it rotating until butter forms. The churned butter is placed in a special jar with other butter and accumulated for a week, at which time it is clarified.

The utensils mentioned, along with the large clay jars which are filled each day with water, our housewife considers necessary to the feeding of her family. With increasing means and increasing family, she may add to the number of these same articles, or she may replace clay with iron, or iron and wood with brass. Or she may add brass cooking utensils and serving dishes of varied sizes and shapes. She may aspire to a serving dish or cup of bell metal, which is more expensive than brass. Beyond this, her desires do not go.

The following list of utensils indicates the variety used, and the relative importance of the different articles, as shown by their frequency. The list includes forty-eight households which represent all castes and all degrees of prosperity. I have divided them roughly into what our village friends call "rich", "moderate", and "poor". They would add to the list "very poor", but these I have included under "poor". There is no way of estimating the actual wealth of a family. Those who appear poor are very apt to have money and jewellery hidden away in a wall or the ground. Indebtedness is no register, as most of the village is in debt:

List of articles, with percentage of rich, moderate, and poor homes, in which each occurs

Local name	Description	Classification of homes		
		5 rich	22 moderate	21 poor
		Per cent.	Per cent.	Per cent.
Chakki . .	Grinding stone	100	100	86
Darenti . .	Light mill for splitting pulses . .	60	24	5
Musal . .	Pole-pestle for husking rice . .	100	100	100
Dahkli . .	Stone mortar for rice . .	100	100	100
Charpai . .	Roped cot on which foods are dried.	100	100	100
Chalni . .	Round wooden sieves strung with thread.	100	100	95
Sup . .	Reed winnowing basket . .	100	100	100
Parat . .	Brass mixing bowl . .	80	50	14
Tasla . .	Iron mixing bowl . .	80	32	. .
Kanthani . .	Wood mixing bowl . .	100	64	62
Katheli . .	Smaller wood mixing bowl . .	100	73	67
Kunra . .	Clay mixing bowl	80	5	. .
Kunri . .	Smaller mixing bowl . .	100	55	24
Pata (w) . .	Wooden rolling board . .	100	100	95
Pata (s) . .	Stone rolling board . .	80	41	33
Belan . .	Wooden rolling pin . .	100	85	95
Tawa . .	Convex iron griddle . .	100	100	100
Karahiya . .	Iron pan for deep fat frying . .	100	91	86
Hansiya . .	Small sickle for cutting vegetables	100	95	86
Sil batta . .	Stone on which spices are ground	100	100	100
Lorhwa . .	Roller for grinding spices . .	100	100	100
Batua . .	Brass kettle for boiling greens . .	100	77	52
Patili . .	Small cooking pot . .	80	45	24
Mathni . .	Churn	80	77	38
Chamcha . .	Long handled iron spoon . .	100	100	90
Kalcha . .	Different type of iron spoon . .	100	100	100
Chamcha (wood)	Wooden spoon	. .	. .	19
Chimta . .	Iron fire tongs	100	86	57
Chimti . .	Smaller iron tongs	20	9	. .
Sansi . .	Tongs curved for lifting kettles . .	80	9	. .
Thara . .	Clay water jar	100	100	100
Kalsa . .	Brass water jar	100	59	. .
Chilamchi . .	Brass wash basin	20	. .	. .
Silafchi . .	Brass basin	20	. .	. .
Thali . .	Brass serving tray	100	95	86
Phul Thali . .	Tray of bell metal	80	45	5
Rakabi . .	Brass plate	80	18	. .
Lota . .	Brass drinking bowl . .	100	100	62
Phul lota . .	Drinking bowl of bell metal . .	40	. .	. .
Bela . .	Brass cup in which food may be served.	100	100	86
Phul bella . .	Bell metal cup	60	27	9
Gilas . .	Brass glass	100	86	67
Ghanti . .	Small brass water vessel . .	80	68	81
Tarazu . .	Balance scales	100	95	76
Pandan . .	Box containing betel condiments	60	9	5
Clay saucers . .	Cups and jars	100	100	100

D—DISHES PREPARED FROM—

Cereals

Every day the village woman makes fresh bread for her family. As has been mentioned, she makes it of wheat, barley, or mixtures of these with pulses, from the spring harvest until the end of the rainy season. From the end of the rains until spring, she makes it of maize, different millets, and perhaps rice, with a wheat mixture occasionally as a treat.

Whatever the grain, she suns it well the day before she uses it. Early on the day when she is to bake it into bread, she, with the help of another woman of the family, grinds and winnows it. She mixes the flour with water in her mixing bowl and kneads it by alternately working it vigorously with both hands, and pounding it with her knuckles. When she considers it "soft enough," she takes up a ball of the dough and works it further in her hands, before patting and rotating it into a round, flat cake. While she turns the cake in her hands, she pinches the edges. She brushes a daub of wet clay over her thin, convex griddle, to keep the cakes from sticking. As each cake is shaped, she flops it on to the griddle. There is only room for one cake at a time. She turns it over with her long, flat iron spoon. While the first cake cooks, she shapes the second. As soon as the first is done well on one side, and slightly on the other, she stands it upright inside the fireplace under the griddle, to toast, while the second cake cooks above, and she shapes a third. Meanwhile, she must keep her fire alive by blowing it and adding fresh fuel. Her fuel may be small twigs, gathered by the children, or dung which she has gathered in her stable, or which the children have collected in fields or on roads, and which she has mixed with chaff and water and shaped into cakes of convenient size for her fireplace. The bread which toasts close besides the fire, must be watched lest the burning fuel touch it, or lest it topple over into the flame. If its edges have been pressed together properly, the cake swells out like a balloon, as the moisture inside turns to steam. At this point, the cook lifts it out with her iron fire tongs, and bangs it against anything convenient to drive out the expanded air. The steps in bread making are listed on page 335.

The women prefer wheat, or mixtures in which wheat appears, not only because of the better flavour, but because wheat flour is more satisfactory to work with. When making wheaten cakes, the housewife can roll them out with her small rolling-pin, after patting them between her hands. Cakes of other grains fall apart if she tries to make them equally thin. Corn cakes are a cross between corn-meal mush, and corn bread. Cakes of the little millet look like clay, before they are baked. They are mealy and have a raw taste. Cakes of sorgum are brown with a purplish tint, and are slightly bitter, and mealy. Cakes of Italian and of Poorman's millet are still less desirable. Wheat is always used for bread which is to be fried in deep fat. When fried, the bread is known as "puri" as distinguished from the toasted bread which is "chapati". Both "puris" and "chapatis" are

covered by the general term "roti". The occasions on which "puris" are required are discussed under the ceremonial significance of food.

Parched grains provide a useful variation in village fare. The grain-parcher is kept busy most of the day when a fresh crop of grain is cut. At other times he keeps his furnace going late each afternoon. The farmer or one of his children brings the grain to be parched. The parcher has a clay furnace in which he burns leaves and twigs. In the furnace he heats clay jars of sand. He mixes the grain with the hot sand and keeps mixing them until the grain has popped or puffed, or browned. Then he sifts out the sand, and gives the grain back to the farmer, after taking out a portion as his pay. The grain thus roasted may be eaten as it is. Or the farmer's wife may grind it coarsely for his morning meal. If there is buttermilk, it is added to the ground, parched grain. If not, water is added, and a little raw sugar, if there is any. If not, there is always salt. The daily ceremonies which must precede any cooking make it impossible to prepare an early cooked breakfast. This ground, parched grain, called "satua," solves the breakfast problem for the farmer, and perhaps for the children. The women and children usually eat cold food left from the day before, but the men scorn this.

If the grain to be parched or roasted for "satua" is fresh, it goes straight to the parcher. But if it is dry—as it is most of the year—the farmer's wife must soak it for twelve hours, and sun it for six hours before her husband carries it to the parcher. Corn, barley, or a combination of barley and gram or of barley and peas, are the most popular. A quantity is sent to the parcher that will supply the family with "satua" for several weeks, or perhaps, months. A prosperous farmer may carry a maund and a half (about one hundred and twenty pounds) to the parcher's, while his poorer neighbour carries about ten pounds. And each hopes to have "satua" enough to feed himself for the same period. When the parched grain is brought home, the women pound it in the stone mortar set in the courtyard floor. This loosens the outer skins. Then they clean it, and grind a week's supply at a time.

At harvest time there is a feast of parched foods in which the parcher has no share. While men rest from harvesting in the fields, or while they sit with their brotherhood after a strenuous day's work, they gather a pile of leaves or stalks and scatter the heads of green grain or the pods of legumes within the pile. They light it from a scrap of smouldering cow-dung, always on hand for lighting pipes. When the blaze dies down, they scatter the charred remains and pick out the smoking heads of grain. These they rub between their palms until the kernels are freed. Some are still green; others are charred black. But the combination is very agreeable. The women and children manage to get a share of the heads for roasting, from the stalks which the men bring home at the close of each day's work in the harvest fields. Peas, wheat, and barley are thus treated and eaten in March and early April. During the harvest at the end of the rains, the heads of both large and small millets are laid on the fire, and the green ears of corn are husked and turned in a blaze or in the embers of a fire of twigs. The corn is field and not

sweet corn, but it is good roasted. These popular products are available to everyone in the village, for at these seasons every able man has a chance to help some farmer. And those who cannot, plan to be present when generous neighbours indulge. The amount of parching done in the fields depends on the good will of the owner of the field. If he is miserly, or work is pressing, he may allow little time for rest and feasting. But ordinarily, it is an accepted part of the day's routine.

Other dishes in which cereals appear, are prepared for certain festivals. These come so seldom that the foods are not of great significance from the point of view of nutrition. In the eyes of the village housewife they are tremendously important and consume much of her conversation and time. They are at the end of this chapter, along with other festive dishes.

Rice is treated differently from the usual cereals. For bread it must be husked with mortar and pestle, then ground. It makes a very soft dough. The cook keeps her hands moist while handling it. It is toasted like any other bread. Rice is used for bread only when there are no other grains on hand.

It is more often used in "khichri." Water is boiled in a brass kettle, and rice and a split pulse are dropped in together and cooked. They may be in equal proportions, or there may be less pulse.

A variation of this with a decidedly different flavour and "feel" is "dal bhat." The rice and split pulse are cooked separately and combined when almost dry. The women of the family drink the rice-water.

Sometimes rice is soaked and later fried in "ghi" (clarified butter) and salted. Oil may not be used for this. "Khir" is a dish which is limited to households where there is enough milk so that all is not needed for "ghi." Rice is boiled in milk and sweetened (one-half pound rice to about three quarts milk). Villagers say that there should be as much raw sugar added as there is rice. Just before serving, a little "ghi" should be added.

A variation of this dish, which is available to a much larger number, is "Raskhir." The juice of the sugarcane is boiled, and rice cooked in it. It has a flavour which we think disagreeably strong, but village folk eat quantities of it with pleasure. A cross between these two, is a dish called "maheri," in which buttermilk and raw sugar are added to cooked rice.

We can get puffed rice in the market town during most of the year. But in the village it only appears at the time of the festival of lights, in the autumn. Then the grain parcher buys the better variety of rice necessary and puffs it in his hot sand. Everyone in the village comes to him to get some. Other occasional uses of rice will be described under special dishes.

STEPS IN MAKING TOASTED BREAD

Maize

Process	Time consumed	Weight before	Weight after
Bringing dung from drying pile and bringing water.	20 minutes.		
Pounding with pestle	3 minutes . .	3 lb. . .	3 lb.
Winnowing, to remove insects, husks, etc.	2 minutes . .	3 lb. . .	2 lb. 13 oz.
Grinding	1 hr. 5 min.	2 lb. 13 oz.	2 lb. 9 oz.
Sifting	2 minutes . .	2 lb. 9 oz.	2 lb. 8 oz.
Making into cakes	45 minutes	Water+2 lb. 8 oz.	4 lb. 3 oz.

Wheat

Pounding with pestle and winnowing to remove insects, husks, etc.	30 minutes.	3 lb. . .	2 lb. 12 oz.
Grinding	1 hour . .	2 lb. 12 oz.	2 lb. 10 oz.
Sifting	3 minutes.	2 lb. 10 oz.	2 lb. 9 oz.
Kneading, rolling, cooking	. .	Water+2 lb. 9 oz.	4 lb.

Number of cakes made from one pound of grain

	Cakes
Maize	3
Wheat	7
Large millet (sorgum)	7
Small millet	6
Tirra (wheat, barley, gram)	6
Gojai (wheat and barley)	7
Rice	7
Barley	8
Bejai (barley and peas)	8
Wheat—grain	8
Wheat (cakes fried in deep fat)	10

⅔c. clarified butter. ⅓c. left after frying.

Pulses

When we visit in a village home, our host always asks hospitably if we have had our "dal roti" (split pulse and bread), which is his idea of a satisfactory meal. The term "dal" is applied primarily to the dish of cooked legumes served with bread. It also applies to any of the pulses, after they have passed through the splitting process and are like split peas. Before this stage there is no inclusive class name, and each pulse is known by its plant title. If turned to some purpose before being split, a special descriptive term is used for the particular product. For instance, split peas may be referred to simply as "dal". If cooked green, they are "matar ki tarkari" (peas as vegetables) or if toasted they are "matar ka chabena". When a man goes to buy "dal", he must then designate from what plant the desired "dal" comes, and his wife in taking "dal" out of storage for some particular dish, is careful to select the split product appropriate for her purpose. For the

ordinary "dal" to be cooked and eaten with bread, she has no choice beyond the supply on hand or her husband's digestive powers. The uses of the pulses, before and after they are split, are outlined at the end of this section.

When "dal" is to be served, the housewife gets out the desired amount the day before. If she has "mung", "urd" or "moth" she pounds it with her pestle, then soaks it overnight. By morning she can rub off the loosened husks under water and skim them from the top. She does not throw the husks away, but saves them and combines them with barley and wheat in making bread. If she is in a hurry, she may omit the soaking and let the family eat husks along with the pulse. Field peas do not require soaking, as husks come off during the splitting. She heats water (about two quarts to a pound of "dal") and while it is heating, she prepares her spices. She grinds red pepper and half a root of turmeric on her spice-stone, and adds them to the boiling water. Then she adds the "dal" and salt (one teaspoonful), and cooks it until it is pulpy when rubbed between the fingers (about thirty minutes). When it is almost done, she grinds coriander (about twenty seeds) and adds it to the "dal". If she has cinnamon, cloves and cardamom, she adds them as well. To improve the flavour further, she may put a teaspoonful of clarified butter on the tip of the big iron spoon, and drop a few chips of asafoetida into it. She heats this until it sizzles, then stirs it into the "dal" and covers it quickly with a wooden lid. Our village friends assure us that the asafoetida prevents flatulence.

The "dal" is quite soupy, but any one brought up in the village knows how to eat it efficiently, if not noiselessly, by dipping it up with pieces of bread. We like the flavour of all the "dals," but "mung", "urd", and pigeon pea have a slippery feeling which is unpleasant. Cooking the husks with the pulse, relieves this somewhat. Field peas may be cooked as these other "dals", making a more appetizing dish, at least for us.

Certain "dal" dishes remind one of meat substitutes, although to the villagers, meat is our "dal" substitute. One such dish is "mungauri" in "jhori". To make this, the farmer's wife takes one pound of "mung" from her store, and soaks it to loosen the skins. She rubs it between her hands and washes it until the pulse is clean. She then grinds it on her spice-stone, handful by handful, until it is a paste. To this mushy product she adds a teaspoon of salt. Into her pan for deep-frying she pours ⅓ cup of mustard oil or "ghi" (clarified butter). If it is mustard oil, she heats it until it becomes clear and the odour is gone. Then she drops the "mung" into the hot oil or "ghi". She does this by taking up a handful and shoving off a bit at a time with her thumb. It forms irregular lumps about three-fourth inches in diameter, which she removes from the hot fat when brown. These may be eaten as they are, but should be served in "jhori". She makes the "jhori" by adding water to more "dal" paste and frying the mixture in a tablespoonful of "ghi". For flavour she adds a few seeds of "methi" (fenugreek). She stirs it occasionally, but does not scrape loose that which sticks to the pan. She then adds turmeric and salt to taste, and still later adds coriander, black and red pepper, one

cardamom, three cloves and a small stick of cinnamon, all ground together. At first this "jhori" is an unappetizing, brown soup somewhat lumpy. The spices turn it to a lighter brown and further cooking makes it a thick gravy. When it is done, the fried cakes of "mungauri" are dropped into it. The product is very much like hamburg cakes in gravy. These same cakes, "mungauri", can be cooked with spiced potatoes, in which case it seems still more like a meat dish.

"Mithori ka jhor" is a similar dish. When a woman makes it, she cleans her "mung", then grinds it like flour with her heavy grinding stone. She adds a touch of asafoetida and red pepper, and makes it into a thin batter. This she drops bit by bit into a kettle of boiling water. As soon as the little cakes or lumps are firm, she takes them out and dries them on a roped cot in the sun. She can put them away and use them from time to time to vary her pulse dishes. When she wishes to serve them she browns them in oil or "ghi", and adds buttermilk, thickened with a flour of gram—one-fourth pound of flour to two-thirds quart of buttermilk.

Still another dish on the meat-cake order is made by preparing and frying small flat cakes of gram flour, and adding buttermilk. The cakes are "danre" and the gravy "karhi". It tastes rather sour, an unfamiliar flavour to us in gravy. It should be eaten with rice or bread of some wheat mixture. The "danre" of gram, is crumbly, whereas the "mungauri" made of "mung" is slightly tough.

Pulses may be combined with cereals in bread. They make a stickier dough which is harder to handle than a dough of wheat or corn. They also add a distinct flavour of partially cooked peas. A favourite village dish is a wheat cake with pulse filling. To make these cakes the housewife makes a dough of wheat flour as for bread, but adds more water to make it softer. To one pound of wheat flour, she makes a filling of six ounces of "urd", soaked and cleaned and rubbed on her spice stone to a paste. She spices it with red pepper, three cloves, a stick of cinnamon, forty coriander seeds, one cardamom and twenty seeds of aniseed, a touch of asafoetida, and a teaspoon of salt. She takes a ball of dough in her hand, flattens it out, lays some of the filling on it and draws up the corners to cover the filling. Then she rolls it out, like a wheat cake, and drops it into hot fat. It puffs and browns, but loses none of its filling if properly prepared. When finished it makes seventeen cakes, weighing two pounds. When eaten hot, these filled cakes are delicious. The difficulty with most of these pulse dishes is that they should be prepared immediately before serving. This is one reason why village feasts are always several hours late.

Although pulses are used chiefly as "dal", dried and split, they make a distinct contribution before reaching this stage. The tender tips of the growing plants of field peas are cooked as greens, or they may be cooked with potatoes as a regular vegetable dish. Small potatoes are cut in half and browned in "ghi", which is flavoured with asafoetida. A little water is added, along with salt, red and black pepper, cloves, coriander, and cardamom. The pea tops are added and the whole is cooked until the potatoes are tender. Green pea pods may be cooked with potatoes in the same way.

The long pods of the cow pea may serve as a vegetable. If they are green enough, they are cut up with the sickle, browned in a little oil or "ghi" with turmeric, black and red pepper, cloves, cinnamon, cardamom, coriander and salt. Then a little water is added, in which the cut up pods are cooked until tender. At the last a thin paste of gram flour and buttermilk is added. If the pods have begun to dry, they must be removed and the peas cooked without them.

The cluster bean is chopped up and cooked in the same way, but without any addition of buttermilk. Most of the water is boiled away. Both these cluster bean and cow-pea can be dried in their pods and stored, to be used later as a vegetable dish.

Like the cereals, pulses are popular when roasted, or parched. Sometimes they are roasted in their pods while green, but ordinarily they are first shelled and dried. When parched they may be eaten just as they are, like the gram which carries many a traveller through days away from home. Or they may be ground coarsely with parched cereals into "satua" for the farmer's breakfast.

Vegetables

The vegetables which are most abundant are often eaten raw between meals, as we eat fruit. During the carrot season one sees the children, especially in the quarters where vegetable growers live, gnawing at raw carrots while they creep after their mothers or play together in the lanes. The same is true when sweet potatoes are plentiful. The sweet potatoes may be partially roasted in a bonfire built in the lane or on the courtyard floor. And in the hot weather, men, women and children may be seen feasting on long green cucumbers. Roadside vendor stalls and religious fairs abound in cheap cucumbers so that one cannot miss them, at home or abroad.

The vegetables which grow less abundantly are cooked and eaten with bread. When there is a vegetable dish, the pulse is usually omitted, unless there is great prosperity in the home, or a guest. Practically the same plan is followed in preparing all vegetables. Seeds and other inedible portions are removed. Most skins have been found edible, and remain. Potatoes are never peeled. Neither are plantains. The vegetable is cut up with the small sickle mentioned. Every village girl learns to brace the handle of the sickle firmly with her toes, and press the vegetable against the blade, one hand on either side of the blade.

A tablespoonful or two of "ghi" where there are milch animals, or mustard oil where there are none, is heated with a little fenugreek or in some cases asafoetida, in the pan for deep frying. When the fenugreek is well browned, the chopped vegetable is added, with enough water to keep it from burning. While it cooks spices are added, varying from salt, pepper and coriander in poorer homes, to these plus cloves, cinnamon and cardamom in prosperous families. The yellow-green, spice-coated, oily product is partly mush and partly in lumps. None of the liquid is poured off. It is eaten with the help of torn-off bits of bread. In appearance it may not be appetizing, but it is delicious.

Pulses used in the homes of Karimpur

Pulse	Comparative amounts used	Uses when not split	Preparation of split product—"Dal"		Use of split product—"Dal"
			Processes at time of harvest	Processes at time consumed	
Pigeon pea . .	More than any other as "dal". But less than gram for total uses.	1. Roasted . .	Soaked, dried. Split. Winnowed. Fried further. Stored.	Pounded (mortar and pestle). Winnowed. Cooked.	1. Boiled with spices. 2. Ground. Made into bread, alone, or with wheat and barley, wheat and gram, or gram alone.
Gram . .	Total used is more than other pulses.	1. Green pods, as vegetable. 2. Roasted plain. . . 3. Soaked, fried in "ghi", salt and pepper. Roasted. 4. Roasted. Ground with wheat and barley, or wheat and peas for morning "satua."	Halfsplit. Winnowed. Dried further. Stored. Other half similarly treated in September for remainder of year.	Pounded. Winnowed. Cooked.	1. Boiled with spices. 2. Ground into flour, to be used in special sweets. 3. Ground and made into bread, alone, with pigeon pea, with wheat and barley, or barley.
Field pea . .	Less than gram or chick pea. More than urd, mung, or moth.	1. Tops of plants as greens. 2. Green pods and green peas as vegetables. 3. Dried, used as vegetable. 4. Roasted in pods. 5. Roasted. Ground with barley, or barley and gram for "satua."	Stored unsplit. Later enough for 3 or 4 months split at a time.	Cleaned . .	1. Boiled. Only eaten in this way when other "dals" are gone. 2. Ground, with barley, or wheat and barley, to make bread.

Pulses used in the homes of Karimpur—(continued)

Pulse	Comparative amounts used	Uses when not split	Preparation of split product—"Dal"		Uses of split product —"Dal"
			Processes at time of harvest	Processes at time consumed	
Urd . .	Less grown than peas. More used as "dal."		Rubbed with oil. Split. Stored.	Pounded. Soaked. Husks rubbed off.	1. Boiled with spices. 2. Cooked with rice. 3. Cooked separately and added to rice. 4. Ground with wheat or wheat and barley for bread. 5. Ground for special cakes.
Mung . .	Slightly less than urd.	Roasted and ground for sweet-cakes.	Rubbed with oil. Split. Stored.	Pounded. Soaked. Husks removed.	1. Boiled with spices. 2. Like urd, above. 3. Ditto. 4. Combined with wheat, or barley, or both, and ground for bread. 5. Ground for sweet-cakes. 6. Ground and used in meat-like dishes.
Moth . .	Little . .	1. Roasted. Ground for sweet-cakes. 2. Roasted alone or with maize and ground for morning "satua."	Rubbed with oil. Split. Stored.	Pounded. Soaked. Husks rubbed off.	1. Cooked with spices. Especially for invalids. 2. Mixed with other pulses and millet, and ground for bread. 3. Combined with "mung", in meat-like dishes.

Cluster-bean.	Little used by men. More for animals.	1. Cut up fresh. Cooked as vegetable. 2. Dried. Stored. Soaked. Cooked as vegetable.			
Cow-pea . .	Little . .	1. Cooked fresh. 2. Dried. Stored. Soaked. Cooked as vegetable.			
String beans . .	Small amounts grown by Kachhi vegetable growers.	1. Cut up. Strings removed. Cooked as vegetable, usually with potatoes.			

Potatoes are a popular base for this vegetable dish during the autumn and winter months. And almost any vegetable may be added to them. Egyptian arum, similar to dasheen corms, is available as potatoes decline, and it makes a satisfactory base. The vegetables used in this conventional vegetable dish, either with potato or Egyptian arum, or with each other, or alone, are carrots, radishes (alone or with tops), sweet potatoes, cauliflower, cabbage, egg plant, okra, yam, tops of young pea plants, field peas and cow peas with or without pods, string beans, and cluster beans, and all the varieties of cucumbers and gourds available. Mushrooms are sometimes included. And fruits, such as mangoes, plantains and melons may be used in this way.

"Reota" is a dish in which the village cook combines vegetables and buttermilk. She may make it of white goose-foot, potato, pumpkin or gourd. She boils the potherb or vegetable, then cooks and drains it. She wraps a bit of asafoetida in cotton, and sprinkles oil on it. This she lays in a smouldering dung cake, and over it she inverts the vessel in which the "reota" is to be prepared. This vessel should be of baked clay, to absorb the fumes better. While the asafoetida fumes, she rubs the vegetable on the spice-stone to a paste. Next she uses the stone for the necessary spices—small red pepper, one seed of black pepper, one teaspoonful coriander seeds, one clove, and about three-fourths teaspoonful salt. Then she mixes the spices in with the vegetable, and rubs them all together on the spice-stone. She sets the clay jar upright and pours buttermilk into it, and puts on the wooden lid quickly. Then she scrapes the vegetable and spices into it, and again puts on the lid. She serves it cold. It looks like a mash, and is quite attractive when green vegetable is used. When one becomes accustomed to the flavour, it is very welcome in hot weather.

Similar to "reota" is the vegetable dish in which buttermilk and gram flour are blended and added to green peas or beans which have been cooked until tender. One other successful vegetable dish is made from the leaf of the Egyptian arum. It is not prepared as much by village women as by those in town. The large leaf is opened out and covered with gram flour and spices. Then it is rolled up like a jelly-roll and sliced off as a roll is sliced. The round, filled slices are fried in "ghi" or oil. It is one of the best tasting of vegetables.

The following table (pages 342 and 343) gives the ordinary procedure followed in preparing vegetables. Vegetables representing various classes and various methods of treatment have been chosen. To us, the differences in method are slight, but to the village cook they are very important.

"Achar," which approaches our pickles, is made from carrots, radishes, beans, and horse-radish, and onions, in low caste homes. When a farmer brings in a generous supply of any of those, his wife uses a portion for "achar." She cuts up the vegetable as for the ordinary vegetable dish. She scrapes and washes carrots and onions. She strings the beans and removes the tough fibrous skin of the horse-radish. The last two she cooks. When prepared, cooked or uncooked, she spreads them in the sun to dry. While they dry, she grinds on her rough spicestone: husked mustard seed, coriander, black pepper, red pepper, turmeric, with perhaps cloves

and big cardamom. She grinds these dry, not moistened as she does for the usual vegetable dish. She puts both vegetables and spices in a clay jar and stirs them together well. Last, she adds enough mustard oil to cover the vegetable with a spicy, oily coat. Beans are ready in twenty-four hours. The others she must shake and sun daily for four or five days. They must all be eaten soon after they are ready, as they rapidly ferment.

Greens

Certain vegetables are boiled in water in a deep kettle, without the addition of fat. When prepared in this way they are designated as "sag"—greens. Potherbs, tops of growing pulse or mustard plants, radish tops, leaves of Egyptian arum, dill, and "palak," a leaf resembling our spinach, may all be cooked as "sag." During a few months, fresh green leaves are available. Some of them are dried and stored for later use.

When a village woman plans to cook "sag," she cuts up the leaves by pushing a bundle of them against the upright blade of her sickle, layer by layer. She has learned to cut them very fine in this way, without slicing her fingers with them. She then washes the leaves and cooks them in water in a straight, deep brass kettle. She uses one quart of water to one pound of vegetables. The water is warmed and salted before she adds the vegetables. After it has begun cooking, she adds "dal" or "mung" or "urd" (one-third cup to one pound vegetables). She is careful to add it so that both "dal" and leaves will be finished at the same time. To lend flavour she adds several slices of dried mango. When she is ready to remove the kettle from the fire, she adds a small amount of wheat flour (about one-fourth cup) slowly while stirring. She explains that "without flour the 'sag' will be by itself and the water by itself." The flour binds the whole. As soon as she removes it from the fire she heats a teaspoonful of "ghi" and a broken up clove or a chop of asafoetida, in her iron spoon over the flame. When it is sizzling she plunges it into the "sag" and covers it quickly with a wooden lid.

An old village woman once taught me this song:

"O daughter-in-law, today I want the leaves, the tender leaves plucked from the tops of young grain in the field.
Tomorrow it will be fenugreek that I require.
On Wednesday I myself shall nip the pale mustard tops and you will cook them delicately in oil.
On the day following a wild potherb will do.
On Friday still another, much more satisfying to the hungry—the yam—Don't forget.
And after that, egg plant will follow, stewed and spiced.
The squash or perhaps the bitter melon, we shall leave for Sunday.
Always remember, O wife of my son, I have no taste for bitter melons, often."

Fruits

Most of the wild fruits, and berries of the peepul and neem trees are eaten raw, and usually when hard and green. Very few of them reach the women in their courtyards. Melons are eaten raw when ripe. When green they are cooked as vegetables. The local plantains are a small, inferior variety, and are preferred

Methods of Preparing Vegetable Dishes

Preliminary process	Cooking procedure ordinarily followed	Spices	Variations in method
Potatoes: Cut up. Skins not removed. Washed after being cut up.	Fat in kettle, with fenugreek, heated. Potatoes added, and enough water to show at edges. Other spices. Cooked until potato tender. Any water left is served with it.	Fenugreek. Black and red pepper. Coriander.	Boiled, peeled, mashed. Cooked in fat in kettle with usual spices plus turmeric. Buttermilk added. Cooked fifteen minutes.
Egyptian arum: Boiled. Skins removed. Water thrown away. Chopped fine.	Fat heated in kettle with fenugreek. Arum and little water added. Spices added. Cooked until tender, and water boils away.	Fenugreek. Pepper. Coriander. Turmeric.	Same as ordinary, except that buttermilk is added in place of water.
Egg plant: Cut up. Washed.	Fat and fenugreek heated in kettle. Egg plant added and a little water. Cooked until tender. Water boils away.	Fenugreek. Dried Mango. Coriander. Pepper.	1. Like ordinary, combined with potatoes. 2. Like ordinary, with gram added.
Mustard tops: Chopped up. Washed. If dried—soaked.	Fat and asafoetida heated in kettle. Mustard and very little water added. Other spices. Water not poured off. Served with it.	Asafoetida. Pepper. Coriander.	1. Like ordinary, combined with potatoes. 2. Boiled as "greens."
Radishes: Cut up, leaves and radishes. Washed.	Fat and asafoetida heated in kettle. Radishes and tops added. Small quantity water. Spices. Cooked until radishes tender and water boiled off.	Asafoetida. Pepper. Coriander.	1. Pickled. 2. Tops cooked as "greens."
Radish seed pods, unripe. Cut up into small pieces. Washed.	Fat and fenugreek heated in kettle. Pods added. Also cut up potatoes, and water enough to show. Spices. Cooked until potatoes tender, and no water left.	Fenugreek. Pepper. Coriander. Low castes—onion.	
Water Chestnuts: Skins removed.	Fat and fenugreek heated in kettle. Nuts added with little water. Spices. Cooked until tender. Water left is poured off.	Fenugreek. Cardamom. Pepper. Turmeric. Coriander.	Roasted.

Turayan: Skins removed. Cut up. (Kind of gourd).	Aniseed and fat heated in kettle. Gourd added. Little water. Spices. Cooked until tender. Water left is poured off.	Turmeric. Coriander. Aniseed. Pepper.	1. Same as ordinary, combined with Egyptian arum. 2. Or cooked and mashed in buttermilk.
Lauka (kind of pumpkin): skin scraped off. Cut up. Seeds removed. When green, skin and seeds remain.	Aniseed and fat heated in kettle. Pumpkin and little water added. Cooked. Spices added. Water boils away.	Aniseed. Pepper. Coriander. Turmeric.	1. May add gram. In this case, is only eaten by immediate family. 2. May be added to buttermilk.
Cluster bean: Cut up. Washed (green in pods).	Asafoetida and fat heated in kettle. Beans added and a little water. Spices. Cooked until tender. Water remaining served with beans.	Asafoetida. Pepper. Coriander.	Same as ordinary, combined with potatoes.
Cauliflower: Cut up, flowers, and stalks all together. Washed.	Fat and fenugreek in deep brass kettle—not frying kettle. Cauliflower added. A little water. Spices added. Cooked until tender. Water kept.	Fenugreek. Blackpepper. Cloves. Coriander. Turmeric. Cardamom. Cinnamon.	When cooked with potatoes, usual frying kettle is used. Red pepper and turmeric mixed with vegetables before cooking. Other spices at end.
Cabbage: Cut up. Washed.	Fat and fenugreek in kettle. Cabbage added. Little water. Spices added. Cooked until tender and water boiled away.	Fenugreek. Blackpepper. Cloves. Coriander. Turmeric. Cardamom. Cinnamon. Low caste—onions.	Same as ordinary, combined with potatoes.
Karela: (Bitter melon). Skin scraped off. Washed. Seeds remain	Melon stuffed with spices, plus dried mango, and onions (if low caste). Partially fried, then water added. Cooked until tender. Water remaining, poured off.	Coriander. Pepper. Fennel. Mustard. Asafoetida. Aniseed.	May add gram to filling.

cooked, in combination with vegetables. "Mahua" blossoms are eaten raw by the children. In case they are unusually plentiful, some are dried and cooked with vegetables later. "Bel" fruit and the wood-apple are usually roasted over a home fire until they burst. Pomegranates are rare. When they do appear, they are eaten raw. Guavas are eaten raw, usually when green. Wood-apples are also eaten raw. The sour fibre of tamarind pods is chewed by the children. Grown-ups soak the pods and make a sweet, cool drink from the liquid.

Lemons are used in "achar"—pickle. The lemons are cut up, and ground spices are rubbed into the exposed inner surfaces. The spices used are cardamom, black pepper, fenugreek, and coriander. The lemons must remain covered with the spices for four or five days before being eaten. If prepared carefully, they will keep for a year. Plums are used to make a preserve. They are cooked, dried, and put into sugarcane juice.

Mangoes are the utility fruit of the village. They are eaten raw, cooked with vegetables, and made into a variety of pickles and preserves. An oil pickle is made by cutting the mango almost in half and removing the stone. Aniseed, red pepper, and salt are ground and added to the fruit, and oil is added to coat the surface. A salty pickle is prepared by cutting the mangoes into four sections and removing the stones. They are put into a clay jar and sprinkled well with salt. Another form of mango preserve is made with sugarcane juice. Green mangoes are soaked and dried, or ripe mangoes are used, without cooking. They are dropped into a jar of strained, fermenting sugarcane juice, and left there for months or years. They are not ready for use until after remaining in the juice two months. Mangoes may be peeled, split, and dried after the stones have been removed. In this form, they may be added to almost anything which lacks flavour. A mango preserve is made by peeling the mangoes and rubbing them to a pulp with the spice-stone and roller. Salt, pepper, coriander and peppermint are added. This "chatni" (chutney) spoils quickly.

Even the kernels of the stones removed from mangoes are used. The stones are split, the kernels taken out, boiled, dried and eaten. They may be roasted, if preferred.

Animal products

Milk and milk products are the chief forms of animal food in the village. Fresh milk is seldom used, unless there is an unusually large supply. When a cow first gives milk, the fresh milk is boiled, and clabbers almost immediately. This is eaten, with or without raw sugar. It is eaten during the next four or five days, as long as the milk is drunk after boiling. After this it is made into "ghi". In most homes all of the milk is reserved for "ghi". The milk is heated slowly in a clay jar, over a nest of smouldering dung-cakes. A little buttermilk is added, and it is set aside all night. By morning it has clabbered. At this stage it is called "dahi", and may be eaten with sugar. In city homes it is often served. But in the village, it seldom stops here, but goes on to butter.

The "dahi" is put into the churn, water is added, and it is churned. When butter forms, it is taken out and put into another jar. The butter is never used, but is collected for eight days. The sour buttermilk which remains in the churn has a variety of uses. The men of the family like it with their "satua"—parched, ground cereal—in the morning. It may be used with vegetables in "reota", described among vegetable dishes. Or it may be cooked with pulses in the dishes which we treat as meat substitutes. If there is not time to use it in any of these combinations, the men drink the buttermilk. Sometimes the children have a drink. The women do not drink it.

The accumulated butter is heated in a deep kettle over the smouldering dung-cakes, or in the kettle for deep-fat frying over the fire-place. It may be heated from one-half to four hours, depending on the fire. Foreign matter which collects on the surface is skimmed off. When the heated butter is removed from the fire it is strained through a cloth. The clear fat which goes through is "ghi". It is regarded as the ideal medium in which to fry foods. Frying is an important process in village cooking, as it must be used for all foods served to guests and for food which members of the family must eat away from home, even though they eat it in their own fields. In the absence of ovens, many things are fried in "ghi" which we would bake. "Ghi" is also used in the preparation of a number of sweet-meats. In prosperous homes, it is an important ingredient in the special dishes given a woman two months before and a month after child birth.

The Brahmans of our village eat no meat. They do not take advantage of the opportunity offered them by the Sacred Law, of eating meat as sacrificial food. Manu provides that "He who eats meat, when he honours the gods and manes, commits no sin, whether he has bought it, or himself has killed (the animal) or has received it as a present from others." V. 31.

It may be that with the giving up of priestly duties, for farming, they have given up priestly privileges as well. If they were to eat meat, without sacrificial intention, they would be guilty of sin. "There is no greater sinner than that (man) who, though not worshipping the gods and manes, seeks to increase (the bulk of) his own flesh by the flesh of other (beings)." V. 52.

The attitude of our Brahmans and of the orthodox Hindus who try to follow them is expressed in the Law. "Meat can never be obtained without injury to living creatures, and injury to sentient beings is detrimental to (the attainment of) heavenly bliss; let him therefore shun (the use of) meat." V. 48. . . . "Having well considered the (disgusting) origin of flesh and the cruelty of fettering and slaying corporeal beings, let him entirely abstain from eating meat." V. 49.

It is this attitude which keeps meat out of sight in the village. The Hindus who eat it, do their buying in the Muhammadan quarters or in their own shadow stables, as quietly as the excitement of bartering allows. The goldsmiths show themselves unorthodox in many ways, one of which is meat-eating. They do not talk about it but every one knows that they eat flesh. One or two carpenter families eat meat, as well as several families below them in the caste scale. They

all limit themselves to goat meat. The cow is revered too highly to be thought of as a source of food. Muhammadans eat as much goat meat as they can afford. Living in a Hindu community they have much the same attitude as their Hindu neighbours toward beef-eating.

Hindus and Muhammadans prepare meat in the same way. They cut it up into small pieces, sear it in fat, add water and spices and cook it. They eat it with rice or bread. Meat dishes were the only ones denied me by my little Hindu cooking-teacher. She warned me that she would never touch our experimental fire-place or utensils if I were to defile them with meat. She knew that we ate meat, but that was not her responsibility, as long as it was kept out of her field of activity.

Sweepers and Dhanuks, two castes of outcastes, are the only ones who will touch pork. After watching the scavenging activities of village swine one is not surprised that their flesh is repulsive to most villagers. Only those who are brought up with the consciousness that they are themselves unclean, could eat it. The men do the butchering and divide the pig into shares. The women cut it up still further, into small pieces which can be fried and spiced, and eaten with bread or rice. The head is the most desirable share.

Fish is not classed with meat. Many eat it who abhor meat. We were surprised at the number of castes represented on the banks of drying ponds, waiting to start their "basket-fishing." On the occasional fishing days in the spring, the whole village smells of frying fish. Only Brahmans and those others who pride themselves on keeping the letter of the Law, abstain.

Eggs are prohibited almost as much as pork. The fact that eggs hold potential life makes it impossible for orthodox Hindus to eat them. In so doing they would be destroying life. A further objection to the eggs is the objection to the chickens that lay them. Chickens are kept by outcastes. No one feeds them and they wander about the lanes near the outcaste section as scavengers. They are scrawny and offensive. The outcaste families who own them eat the few eggs which they lay.

E—FESTIVAL DISHES

Special dishes are reserved for days of religious festivals, and weddings. From the passing of one festival to the coming of the next housewives and children, and often the men, recount the special dishes they have had or are going to have. A meal of toasted millet bread and stewed pulse tastes better if one thinks while eating it, of sweetmeats fried in "ghi". The pleasure of anticipation is granted to all, as those with much share with their dependents on these occasions.

"Puris"—bread of finely ground wheat flour, fried in "ghi"—appear on all feast days. The other articles vary. "Holi" is the great festival of the spring. With its coming there appear "gojha", "yasse", "chandia", "puri", "kachauri" and "halwa". For "gojha", wheat flour is ground fine, sifted through a coarse cloth, kneaded and shaped into cakes as for bread. The cakes are dried for several hours, then fried in deep fat. When fried, they are pounded into small pieces and dried

again. When well dried, they are ground in the stone flour mill, and put through the thread-strung sieve. The sifted material is combined with black pepper and crude sugar and again sifted. Raisins and "chiraunji" (small nuts) and cut up fresh cocoanut are then mixed with it. This is the filling. The crust is made of fine wheat flour, kneaded and rolled out as for small "puris". Each cake is flattened out in the hand and filled with the mixture. Then one side of the cake is folded over and the edges pressed together, very much like small turnovers. As rapidly as the turnovers are prepared they are fried in deep fat.

"Yassee" is made of rice. The rice is husked, soaked, and pounded fine. It is then beaten up with a little warm "ghi" or oil, and raw sugar is added while beating.

"Chandia" is made of split "urd." The "urd" is soaked and its husks removed. Then it is rubbed to a thick paste, together with asafoetida and salt. This paste is spread on a wet cloth in a small circle (about four inches in diameter). A hole is cut in the centre, and it is lifted from the cloth, fried in deep fat and then added to buttermilk. "Puri" and "kachauri" have been described under cereal foods.

"Halwa" is prepared by making "puris" and grinding them up as for "gojha". One pound of this is browned well in one pound of "ghi", and combined with one pound raw sugar. A little water may be added if necessary. It is like a stiff mush, patted out and cut into cubes. Raisins may be added. In town there are many variations of "halwa", such as adding grated carrot, nuts and cocoanut. But in the village, the simple form is adhered to.

In the spring, just before the last field of the winter crops is cut, the farmer's wife makes "sira". For this she browns wheat flour in "ghi". She melts raw sugar in a small quantity of water and adds hot water to it. Then she adds the browned flour and raisins and cocoanut and serves it.

The wedding season comes in May and June. Wedding parties go from our village to be entertained in other villages and wedding parties from other villages are feasted by us. There are "puris", "kachauris," "halwa", and fried vegetables and pulse dishes, all of which have been described. A special dish is called "tikian". It is made of gram flour, mixed with enough water to make a stiff dough. In a deep kettle, water is heated—about three quarts water to one pound flour. The stiff dough is made into little flat round cakes, a little larger than the palm of the hand. These cakes are dropped into the boiling water and boiled about twenty minutes, until tough. They are then lifted out and spread on a tray to cool. Each cake is cut in half, and then into cross-wise strips. The gram flour inside looks packed and uncooked. Salt, red pepper and turmeric are ground and mixed through the strips. The sticky surfaces hold the spices. Two ounces of "ghi" and a pinch of asafoetida are heated in the deep-fat frying kettle and the spiced strips are fried in it. When the strips are well browned, water is added almost to the top of the kettle. It is cooked until most of the water boils away, when salt, cloves, cardamom, and black pepper are added. It looks like noodles in thick brown gravy and tastes better than it looks.

Two festival dishes go through the same steps, but one is sweetened and one is made salty. The sweet cakes are "gul-gula" and the salty ones are "pakauri". To a pound of wheat flour a pound of melted raw sugar is added, also a small ginger root and a large cardamom. Water is added until the batter is like that for ginger bread. The frying kettle is half filled with "ghi" or oil, and heated. A handful of batter is dropped into the fat. The cakes thus dropped puff out and turn a rich brown. They are delicious, like doughnuts, with a strong molasses flavour. For the salty cakes, salt and asafoetida are added to the flour and the same procedure is followed as above. We prefer the salty cakes.

At wedding time mangoes are at their height, and appear in many forms. In addition to the preserves described, a special mango dish is prepared, called "Amiyan chinghora". Turmeric, pepper, salt and coriander are ground together. Oil is put into the frying kettle and the spices are heated in it. Gram flour and mangoes have previously been peeled and stoned. When it is ready to remove from the fire, heated asafoetida is stirred into it.

In August, during the rains, there is a festival which is a happy one for the girls. Most brides, and often women long-married, go to their father's homes for this festival, "Raksha Bandan". The dish most definitely associated with this festival is "samai". Every woman makes it. She makes a stiff dough of the finest wheat flour she can grind. She inverts a large clay jar, and on its bottom she rolls the dough into a long thin string like vermicelli. The dried branch of a tree is stood on a roped cot, and the vermicelli is draped over it. When it is dry, the whole family enjoys it, mixing it with melted raw sugar.

In the Autumn comes the Feast of Lights which is another occasion worthy of feasts. Puffed rice, plain or sweetened is the special dish for this festival. And there is "lapasi". A thin sweetened flour batter is poured into hot fat and stirred until it is a smooth thick brown sauce. This is poured out on a tray where it becomes firm almost immediately. It is patted out and cut into squares for serving. "Lapasi" may be made of wheat, maize, or barley, and may be sweetened or salted.

Another dish associated with the Feast of Lights is "pitaua". Spiked millet or great millet is ground, and combined with raw sugar and sesame seeds. It is worked into a dough, and shaped piece by piece into round flat cakes, about six inches in diameter and three-eighths inches thick. These are fried. Maize may be used in place of the millet, in which case salt is added instead of sesame. "Halwa", described under the Spring Festival, also appears on the Feast of Lights.

At any time during the year which is proclaimed auspicious, a man may give what is called "Katha". He calls in a priest to read from the sacred books, and invites all relatives within reach to come and listen, and feast. By giving a "Katha", a man gains much merit. At the feast he serves the guests mango preserve, with "Channa mirt". "Channa mirt" is a mixture of cow's milk, leaves of the holy basil tree, Ganges water, sugar, curds, and gram. It is served in little clay cups, or poured into the hands of guests. At the same time, two wheat flour dishes are served. One of these is simply wheat flour mixed with hot "ghi" and

then with raw sugar. For the other, wheat flour is made into a stiff dough with water and melted raw sugar. The dough is shaped into a long slender roll from which small slices are cut and fried in deep fat.

Among the special dishes of the village must be included those prepared for women before and after their babies are born. One such dish is "mewa kilaurna", given to a woman during the early nursing period. Cocoanut, almonds, pistachies, raisins, dried dates, are all chopped together and heated in "ghi". Gum from the gum acacia tree is added. Raw sugar and water are boiled together until it forms a thread. It is stirred into the prepared condiments and the whole is beaten and shaped into balls. It resembles Persian sweets. This is only available in the better homes.

Another special food given a woman after child-birth is "harira". Aniseed, coriander, turmeric, fennel and "ajwain" (caryota copticum) are ground together. Equal weights of these and "ghi" are combined and added to their total weight of raw sugar. A little water is added. Both of these sweets are supposed to add strength, and increase the flow of milk.

IV—FOOD PRACTICES

Certain practices in regard to food have become customary in Karimpur. They are the product of the experiences of generations. Some of them are common to all Hindu communities, others are limited to the Ganges area and still others are found only in our district. There are two sets of these practices. One set is associated with the good, and the other with the harm which may come to a person through food. Both have the support of custom, but those associated with the good which food may do, are such a simple part of daily living that one is hardly aware of them. They encourage the distribution and use of foods shown by experience to be beneficial. Those practices associated with the harm which may come through food receive much more emphasis. They take the form of food taboos, supported by religious law and ceremony.

A—FOOD TABOOS

Blunt, in his discussion of the caste system of Northern India, lists seven kinds of food taboos. (10).

> "The food taboos of Hindu life complicate it to an almost incredible degree: and as has many a time been pointed out, prevent 'the growth of the good fellowship which we are wont to cement at the dinner table.'
>
> "Hindu food taboos are of several kinds:
>
> 1. The commensal taboo—which lays down the persons in whose company a man may eat food.
>
> 2. The cooking taboo—which lays down the persons who may cook the food that a man eats.

(10) See References.

3. The food taboo—which lays down what kinds of food a man may eat.

4. The eating taboo—which lays down proper ritual at a meal.

5. The drinking taboo—which lays down the persons from whom a man may take water.

6. The smoking taboo—which lays down the persons whose pipe a man may smoke, and in whose company he may smoke.

7. The vessels taboo—which lays down the nature of the vessels that a man may use for eating, drinking, and cooking."

To a new-comer, these and related taboos seem an absurd waste of time. But as we observed the measures which we took to protect ourselves from disease in community with no sewers, no screens and no quarantine rules, we admired the skill with which high caste Hindus had formulated rules with all the prestige of ceremonialism, which served to protect them and their progeny from the dangers that apparently lurk in food. We tried to explain our reluctance to eat in village homes in terms of flies, and small-pox and cholera germs. But our village friends pleasantly ignored our terminology and explained our practices to each other in their own familiar terms of caste rules. They were relieved to find that although we mingled recklessly with all castes, we still maintained certain prohibitions. This discovery made us more comprehensible to them.

The Brahmans at the top of the caste scale, are meticulous in their observances of the religious law. This includes bodily cleanliness. Even our busy Brahman farmers try to bathe every day. A man stands beside a well and pours water, freshly drawn, over his body, while he repeats prayers. He wears his loin cloth while bathing and changes it for a dry one if he has it, after the ceremony is completed. After this bath he is ready to eat. No one is supposed to touch him until he has finished his food. Bose, in describing Hindu customs in Bengal, writes, "When Hindus sit together to eat, their seats are generally wooden planks or 'Kusa' grass seats placed on the floor. These seats must not touch one another and no Hindu will touch another person who is also eating by his side. Among Brahmins this rule is very strictly observed. No one except the mother and the wife can touch a Brahmin while he is eating; if he does, he will stop eating and get up and wash his hands and mouth. This is a most barbarous custom. Some Brahmins do not allow their wives to touch them while they are eating. As the mother is regarded as a goddess by all Hindus they make an exception always in her case." (11)

The Brahman wife, who serves her husband, has also bathed or at least washed her hands before preparing his food.

S. N. Jafri, Deputy Director of Public Information of the Government of India, gives an interesting picture of eating in a Hindu home of the United Provinces.

(11) See References.

"The system of taking food by the Hindu tenantry, or for the matter of that all Hindus except those who are influenced by modernism, is unique.

"They sit in a part of the floor of the kitchen which is called 'chauka' and is meant as a place for taking food. Before eating they take off all their clothes except the 'dhotees,' or the piece of cloth that goes round the waist and answers the place of trousers. In fact, other pieces are very seldom put on after bathing. The coat, the cap, and the turban, are all taken off, and a man eats with his body and head uncovered. Shoes are of course left at the door of the house. To woollen stuffs, they believe, there attaches no ceremonial uncleanliness and these they use while eating and worshipping, though they get them washed by bleachers, members of an inferior caste. In very cold weather, while eating, they generally throw a blanket over them.

"The plates containing the food are put on the 'chauka,' because placing the food anywhere else would pollute it and then it could not be eaten. All the food that is cooked is not placed in the 'chauka' at once, but only the requisite quantity. The woman of the family who is the principal cook at the time, or officiates in the kitchen, serves the food for the eater or eaters. She sits near the fireplace, where the 'chauka' is situated. The man squats, in which case he has a small smooth board under him; his knees stick up close to his chest, the joint of the left arm and hand rest upon the left knee and it is thus the hand is supported while stretched out.

"Both Hindus and Muslims eat with their fingers; knives and forks are unknown—the food is of such a kind that the fingers manage to carry it to the mouth, and thus they can eat very conveniently with one hand.

"A Hindu at the time of eating must not be touched by one of inferior caste or by a non-Hindu for, if he were, he would immediately rise and not take another mouthful, even if he had to go without food the whole day; he would also throw out that which he might have in his mouth. He would never eat food prepared by a non-Hindu or even a Hindu of an inferior caste; and to some the shadow of a low caste man falling on their victuals renders them unfit to eat. A Hindu's food is of two kinds, 'kachcha khana' and 'pakka khana.' All the above-mentioned ceremonies are required for 'kachcha khana.' No ceremonial uncleanliness attaches to dry things, such as flour and grain, and none also to fruits. Such things a man of higher caste can receive from a man of lower degree." (12)

Before one can attempt to understand the intricacies of the food "Thou shalt nots" of a Hindu community, he must know the distinction between "kachcha" and "pakka" food. Ghurye in his presentation of Caste and Race in India, gives one of the clearest statements of this distinction that I have found.

"Restrictions on feeding and social intercourse. There are minute rules as to what sort of food or drink can be accepted by a person and from what castes. But there is very great diversity in this matter. The practices in the matter of food and social intercourse divide India into two broad belts. Hindustan proper (our section of India), castes can be divided into five group; first, the twice-born castes; second, those castes at whose hands the twice-born can take 'Pakka' food; third, those castes at whose hands the twice-born cannot accept any kind of food but may take water; fourth, castes that are not untouchable yet are such that water from them cannot be used by the twice-born; last come all those castes whose touch defiles not only the twice-born, but any orthodox Hindu. All food is divided into two classes. 'Kachcha' and 'Pakka,' the former being any food in the cooking of which water has been used, and the latter all food cooked in 'ghi' without the addition of water. As a rule a man will never eat 'Kachcha' food unless it is prepared by a fellow casteman, which in actual practice means a member of his own endogamous group, whether it be caste or sub-caste, or else by his Brahmin 'Guru' or spiritual guide. But in practice most castes seem to take no objection to 'Kachcha' food from a Brahmin. A Brahmin can accept 'Kachcha' food at the hands of no other caste; nay, some of them, like the Kanaujia Brahmins, are so punctilious about these restrictions that, as a proverb has it three Kanaujias require no less than thirteen hearths. As for the 'Pakka' food, it may be taken by a Brahmin at the hands of some of the castes only. A man of higher caste cannot accept 'Kachcha' food from one of the lower, though the latter may regale himself with similar food offered by a member of one of the castes accepted to be higher than his own." (13).

(12), (13) See References.

Blunt gives the explanation of the distinction between the two kinds of food.

> "The Hindu draws a distinction between 'Kachcha' food, which is cooked in water, and 'Pakka' food, which is cooked with 'ghi' (clarified butter). This distinction depends on the principle that 'ghi' like all the products of the sacred cow, protects from impurity: and since such protection is the object of all food taboos, this convenient fiction enables the Hindu to be less particular in the case of 'pakka' than of 'kachcha' food, and to relax his restrictions accordingly." (14).

In our village "kachcha" food is an exclusive, family-only product. But on certain definitely fixed occasions a Hindu may eat "pakka" food, prepared by others than members of his own family. The persons who may cook this food are all listed in the rules of his particular caste. In this way, although he ventures to dine abroad he is still somewhat protected. The persons who may cook the feast of "pakka" food, which he shares must be his equals or superiors in the caste scale. This guarantees that they will be at least as clean as he is, if not cleaner, in the care of their bodies and their food. If he is a Brahman, he is supposed to feast only at the house of a Brahman, with the understanding that the food has been prepared by members of the Brahman household, Brahman servants, or servants of water-carrier caste. He takes for granted that any sweets too elaborate to be prepared at home, have come from a *bona fide* "halwai," maker of sweets. If doubt arises about the source of any article of food, the Brahman guest does not hesitate to make pointed inquiries of his host about it, before touching it.

The following is just a short section from pages and pages of laws stating from whom a Brahman shall not accept food:

> "The food of a king impairs his a Brahman's vigour, the food of a Sudra his excellence in sacred learning, the food of a goldsmith his longevity, that of a leather-cutter his fame. The food of an artisan destroys his offspring, that of a washerman his (bodily) strength." Code of Manu. IV. 218 and 219.

The Brahmans of Karimpur treat their goldsmith neighbours as being worthy of becoming their hosts on special occasions. At the lower end of the caste scale are the Sudras. They can eat "pakka" food or drink water from members of the long line of castes above them. But better than any other food for the Sudra is that which a Brahman has touched.

> "Sudras who live according to the law, shall each month shave (their heads); their mode of purification (shall be) the same as that of Vaisyas, and their food the fragments of an Aryan's meal." Code of Manu. V. 140.

Below the Sudras are the outcastes. They haunt the weddings and other feasts of any caste, ready to hurry in ahead of the dogs and crows, to gather up the scraps left by the guests on their leaf plates. These left-overs they carry home in baskets or ends of scarves or loin cloths. They eat what they can at the time, and dry out the rest to be eaten later. No one worries about protecting the outcastes from possible contamination.

(14) See References.

Our years in India convinced us that experience had taught the law-makers well—at least for their own benefit—in the matter of "kachcha" and "pakka" food. We found ourselves unconsciously following their practice. We learned that we could safely go to a wedding feast in a village home, where we would hesitate to eat the daily food. This was because the wedding foods were all "pakka"—fried in hot "ghi" and served at once. It was not the sacred source of the "ghi" which influenced us, but the fact that it was sizzling hot.

The weighty distinction between "kachcha" and "pakka" food complicates food preparation for the village housewife. When her husband and sons eat in the family courtyard, everything may be "kachcha." She makes the ordinary cereal cakes and toasts them, and she may cook "sag" (boiled green vegetables) or pulses. If one of the men wants his food sent to the fields where he is working, she must prepare "pakka" food for him. She cannot send boiled food to the fields, as it would be "kachcha," and "kachcha" food may not be eaten in the fields where there is a possibility that the food or the eater might be touched. So she must fry the vegetables, and she is supposed to fry the cereal cakes in deep fat. These fried cakes are made only of pure wheat flour, which she cannot afford to use often. Neither can she afford large amounts of "ghi" or oil for deep fat frying. So she toasts cakes of mixed flour in the usual way, and sprinkles a little "ghi" or oil over those which are to be carried to the worker in the fields, and pronounces them "pakka". Thus she keeps the law with a few drops of "ghi". But her problem does not end here. If she should prepare her "kachcha" food such as toasted cakes and pulse first, then any food which she prepares after it becomes "kachcha", even though it would seem to be "pakka," by being fried in "ghi". It can then be eaten only by members of the family within the courtyard. If she has "pakka" food to prepare she must finish it first, and set it aside in a prescribed place, and after that, cook the "kachcha" food. She finds it easier whenever possible, to have everything fried in "ghi"—"pakka", or everything "kachcha".

"Kachcha" food must be eaten immediately. If a woman discovers that she has prepared more of some "kachcha" food, such as boiled vegetables or pulse, than will be used at noon, she can mud plaster a corner near her fire and set some of the food there to be kept for the evening meal of the same day. But she must do this before any one has been served. If any "kachcha" food is left after a meal has been served, the women and children may eat it later on in the day or even the next morning. The men will not touch it. One appreciates this precaution after observing what might walk over food standing on the floor, even though it be in a special corner, where no human treads.

Drinking water is protected from contamination by a number of laws. Only three Brahman courtyards in Karimpur are large enough for wells. The other wells—19 in all—are along the lanes and paths. Each well may be used by certain families, and must not be touched by others. Brahman women and other women kept in seclusion cannot leave their courtyards. Women of water-carrier caste draw their water for them. Whoever uses the well lets his or her jar down into

the water. This makes it important that unclean castes and strangers be prohibited from using a high caste well. We were not allowed to get our water from any of the village wells, as the boy who carried our water was a leather-worker, and the well of the leather-workers was too far away to be used. So our water came from an irrigation well in our grove and sometimes from one in the fields. We were not as particular as our village friends about who shared our well. In place of caste prohibitions, we resorted to thorough boiling. When cholera broke out in the village one summer, the district sanitary department sent out men armed with potassium permanganate. They did not limit themselves to the wells used by contaminated households but treated all wells, for safety. Someone told our people that the permanganate was poison. As we went the rounds to re-assure them we found men laboriously trying to empty the wells of the red water, a jarful of water at a time. If the permanganate had been somehow related to ceremonial purification or if waterboiling could have been substituted and given some spirit-appeasing significance, it would have been accepted readily. But being introduced officiously, without explanation, it was upsetting.

Dishes in which food is prepared or served are carefully guarded. They are used for the immediate family only. Red clay dishes and clay cups without handles are used for guests and thrown away. They are never used a second time. This is as satisfactory as our rinsing with boiling water and it is much easier. At least so our young sons thought when we washed dishes after our own guests had departed. If clay dishes are too expensive, a host may serve his guests on plates of large leaves bound together with twigs.

At a feast, nothing is ever passed around. The host or his sons serve the men, and his womenfolk serve the women, after the men have finished. As a server moves from guest to guest he is careful not to touch anyone with his garments and he is still more careful not to touch his hands, or the big iron serving-spoon against the plate of a guest. This would render the spoon, himself, and the serving dish in his hand unclean.

Food dropped on the floor must not be eaten. The advantages of this are obvious, especially where the floors are the earth, and children and animals relieve themselves anywhere. The villager has his own explanation, expressed in an old saying, "If edibles at the time of eating drop down they are taken by the shadowy spirits and should not be picked up and eaten. If you do eat, you are sure to be possessed by the spirits who will harass you much." (15)

There are other food regulations, the burden of which rests on the women. These have to do with the ceremonies of food preparation. In the morning as soon as her grinding is finished, a woman plasters her little fireplace and the floor all around it with fresh clay. The plastered floor space extends about three feet out

(15) See References.

from the fireplace. The clay she uses is not ordinary clay. It is collected from the edge of a particular pond, by the children of the family if she is too high in caste to get it herself. She mixes the clay with a little water and a bit of cow-dung in her mixing bowl, and plasters it on the surface of the fireplace and floor with a rag kept for the purpose. When the plastering has been done, the fireplace and the plastered area around it are "purified". No one must go near them. Even the children of the family know that they must not approach it. It was not until I had my own fireplace that I appreciated the importance of this. In the absence of a kitchen table, it is necessary to have some place where one can put eatables and utensils and know that they will not be walked over. My fireplace was under a tree in our grove, with children playing all around, and farmers stopping to add their advice to that of my instructor. And only once did anyone approach this sanctum. That one was a little toddler of washerman caste. My teacher rushed at the child in a fury, and a torrent of reminders of her unworthy birth. The child fled, and we had no lesson that day. The fireplace had to go through a fresh mud-plastering before it could be used again.

While the fireplace is drying, a woman may perform any of the tasks which do not demand strict purity. She may churn or make her fuel cakes of dung or chop vegetables. When everything is collected for the meal—flour, water, pulse or vegetable, and utensils and spices—she bathes. This she does by standing in a sunny part of the courtyard and pouring water over herself and her clothes. Then she changes to a "dhoti", a scant garment made of one piece of cloth draped around the body and over the head. She never allows the village washerman to touch this garment, but rinses it out at home herself. The washerman's touch would indirectly defile her, and the food she touches. Women lower than the goldsmiths in caste, let handwashing take the place of the bathing ceremony.

When bathed, or washed, the woman enters the plastered area, by her fireplace, taking all of her materials and utensils with her. From this moment until after the men have been served, she must not leave it. The other women help with the preliminaries, but only the one who is ceremonially and physically clean, may attend to the final cooking. She alone may serve the men their food as they come and sit near her. In Karimpur the family never eats together, and even the men seldom eat together. Each one comes in when he is free, eats his meal in silence, and leaves the courtyard at once. The cook must wait until every man has been served before she is allowed to leave her post. Thus does a woman do her share in protecting the food which she gives her menfolk. For her own food, there are many less rules. She and the other women eat what the men leave. While they eat they are free to sit anywhere within the courtyard. Women are of little importance in the village interpretation of the Hindu code.

B—NUTRITION PRACTICES

The second set of food practices, mentioned at the beginning of this chapter, are much less formal and less obvious than the ones just discussed. They have risen from experience which has demonstrated the good effects which apparently result from the eating of certain foods. Most of these practices are simply an expression of physical desire for certain foods. I have called them "nutrition practices," as they express the village way of meeting body needs.

First there is the custom of sharing raw products. If there were barbed wire fences around orchards and fields our poorer families would suffer. As it is, each family of low caste with low food supply is dependant upon, and attached by custom to one or more high caste, prosperous families whom they call their patrons. When leguminous plants and mustard plants are young and their tops are tender, children of poor homes are allowed to pick them in the fields of their patrons. They gather enough so that their families have what they want to eat fresh, with some left over to dry and store for later use. The children also go into the fields of patrons and dig up certain of the green leaves which grow without tending, close to the ground. There are a number of those listed in the food table (p. 372).

With a diet based on cereals and legumes, supplemented with vegetables which are chiefly of the pumpkin and tuber varieties, villagefolk need the minerals and the vitamins which these green leaves offer. And nature and custom have combined to make the leaves available, not just to the prosperous but to all.

The same is true of sugarcane. From the time it is ripe until it is cut and pressed, one sees children and men of all castes sucking and chewing at the stalks. In so doing they are supplying their bodies with the calcium of which they get little in their low-milk diet. In the cane juice there are also the calories which they need.

At harvest time sharing reaches its high point. Every man and boy in the village has a chance to work in the harvest fields. He may be a carpenter, a potter, or a leather-worker the rest of the year, but at this time he turns farm-hand. The untouchables are the only men excluded. We asked why? One of the farmers explained, "When they work just a little while, they perspire and then they complain because they are tired." We thought at first that this was an excuse for keeping the untouchables out of the fields. One expects to have real reasons veiled. But after seeing the untouchables at lighter field work, and their quick tiring, we agreed that the farmer had expressed his actual thought. A Multan proverb says, "He that eats a 'ser' (from 2 to 3 pounds) works like a lion, but he that eats only a quarter of a 'ser' works like wood-ashes." And we wondered if this might not help explain the seeming laziness of the untouchables who have no fields of their own and who get only a meagre share from others.

The men of all castes above the untouchables, and some of the low caste women, work daily while the harvest lasts. And every night each one carries

home a headload of grain from the field just cut. This gives them varieties of grain and pulse which they would not otherwise have.

At harvest time, women who cannot work all day, follow the harvesters, gleaning. A woman may glean in any of the fields belonging to her husband's patrons. In a few hours she can gather up several pounds of heads of grain—grain which would otherwise feed the crows.

At harvest time representatives of families of craftsmen and serving castes appear at the fields of patrons at the proper time, to claim their shares. Even the outcastes have rights at this time. No questions are asked. Everyone knows whose duty it is to give, and whose right it is to receive, and the proper amount. The ethics of this system of payment may be questioned, but it assures the low caste and outcaste families of a variety of cereals and pulses which they would not otherwise get, either from their own fields or from the bazaar.

In the fruit crops, we find a high degree of sharing. As has been noted, mangoes may be gathered by any member of the village, in any grove of the village. And mangoes are apparently their chief source of Vitamin C. The tamarind pods are available to all. And long ago Sanskrit medicine found in the tamarind, a quality now recognized as anti-scorbutic.

The children are the ones who let their physical needs direct their foraging. None of the edible fruits miss them. The wild ones which they eat, we know little about. But we feel sure that they must supply some Vitamin C, and calories, and perhaps some of the iron which they need. The gum from the gum acacia tree of which they are particularly fond, must add calories, if nothing more. We tried most of the strange fruits which they brought us to sample. A few were delicious, but we would not recommend many of them for flavour. The only offering which we absolutely declined was something which they scraped from the trees of our grove. It was apparently the deposit of mud made by white ants to serve as their passageway up the side of the tree. What the children got from it which was satisfying, I cannot imagine.

When the outcastes butcher a pig they treat the head as the choicest portion. It reminds us of the boar's head, praised by our own forefathers. The outcastes have not been told why the pig's head appeals to them especially. They only know that they like it. Here, as with the children and the fruits, nature guides them.

The people of Karimpur have learned to save and eat many things which we, with our plenty, have wasted. It is comparatively recently that we have been taught that the water in which potaoes and certain other vegetables have been boiled is valuable. We try to save some of the water for soups. In Karimpur the water which is added to vegetables is so small in quantity that little or none remains when the vegetable is cooked. What does remain is eaten along with the vegetable. My village friends were horrified when they heard that in some places this water is thrown away.

They hate to throw anything away. When they cook vegetables, they never remove the skins, unless too tough for chewing. When their grain is threshed some of the finer husks remain. These come loose during the grinding of the grain into flour and are separated in the sifting. But the women are careful not to lose them. They put some back into the flour and save the rest to be mixed in with other flour which has less roughage. When I tell them that in America we separate bran, and sell it in packages apart from the flour, at a price which seems fabulous to them, they think that we must be very stupid, or at least shockingly extravagant.

When a woman prepares a batter of any of the buttermilk or pulse mixtures in her mixing basin she does the stirring with her right hand, and scrapes the basin clean with the same hand. But she is not satisfied with this. She pours water into the mixing basin, washes the basin and her hand and pours the washed product into the frying pan or jar or other container along with the original preparation. As nothing is measured exactly, this additional liquid makes little difference. And the cook prefers to have it in the soup, rather than in her open mud drain which is already messy and alive with flies.

As I walk through the village lanes on a festival day, I meet the women of serving castes, and outcaste women, going from door to door among their patrons. At each door they stand until one of the women of the patron's household tosses out several "puris" and the particular cakes or sweets associated with the occasion. If the serving woman thinks that she has not received her due, she says so, and stands talking about it until the women of the house give her something more, to get rid of her. If they think that she wants more than she should have, they shout at her until she is convinced that waiting will not profit her, and leaves. This sort of tumult alarmed me, until I learned that it was a perfectly friendly way of settling the amount of payment due. A definite payment in cash would seem more satisfactory to us. But cash, in the village is not as useful as food, especially the kind of food which is distributed on festival days. In the homes from which these low caste and outcaste women come, there is no wheat except that distributed at harvest time. They own no cows or buffaloes, and therefore have no "ghi". Meanwhile, there is plenty of wheat and "ghi" in the prosperous homes. And this method of handing them out in the form of festival cakes, assures the donors of religious merit, while giving the recipients and their children something which their bodies need.

There are sometimes other rare things used, to fill the cakes, such as cocoanut and dried dates. These help still further to meet neglected needs. It seems like an unpleasant welfare method to us. But both parties regard it as an exciting and profitable procedure. Life would be dull without the anticipation of festivals. And as yet the West has not discovered a method of caring for the unfed, successful enough to be offered as an improvement.

Among villagefolk there is a conviction that certain foods have special qualities. Some foods are "heating", while others are "cooling." We noticed that patients almost always asked what food they should eat. Knowing little about their foods, we hesitated to advise. But there was always someone around ready to speak with authority. If the patient suffered from toothache or earache, or a cold, the term "heating food" almost always occurred somewhere in the lengthy advice. If the patient had fever, "cooling food" always occurred. The reasons also seemed important. In cold weather when a person had digestive difficulties, "heating foods" were advised. In similar cases in hot weather, "cooling foods" were recommended. We collected a list of the foods which we heard mentioned in these two classes. "Cooling foods" include: buttermilk; sugarcane juice; bread of barley flour; tips of gram plants; "raskhir"; a combination of rice and sugarcane juice; radishes; carrots; Egyptian arum, or dasheen; and water-chestnuts. "Heating foods" include: bread of spiked millet; "dal" of pigeon pea; raw sugar; milk; potatoes; corn and sesamum oil. As I recall some of these foods, in the setting of an Indian hot season, I have reactions towards them, similar to those suggested by the villagers. But I have no adequate explanations of them as two distinct classes. There is no one quality running through either class which might explain its designation. Further analysis of Indian foods may disclose a reason. At present, I simply offer the lists as demonstrating the effort of village folk to express the possible effects of food.

Another class of foods accepted in the village is that of "strengthening" foods. These are supposed to give superior strength to the already strong, or to restore strength to the weak. The goldsmith brothers who act as village wrestlers, and are the acknowledged "strong men", eat almonds and pistachies, both of which are luxuries from the Mainpuri bazaar. While in training, they give up meat, and add milk to their usual diet.

Strength-giving foods are considered important for expectant and nursing mothers. Two dishes reserved for them, "mewa kilaurna" and "Harira", are described in the section on festival dishes. These are too expensive for most homes, where simpler festival dishes of wheat or gram flour, rich in "ghi" and raw sugar, are substituted. Cocoanut and "phaphola" (nymphaea lotus) are included if possible, even though they must be begged.

For anyone who has become very weak, without particular reason, mixtures like the two following are recommended by the local practitioners. Three drams of roots of the okra, and twelve black pepper corns, ground together. This is one dose. Or, one green seed pod of the gum acacia tree and ten black pepper corns. Grind and make into sherbet, with one cup of water. Sweeten to taste. Drink this every morning until strength returns.

Sunshine is an acknowledged blessing in the village. Every morning good Brahman farmers chant hymns in its praise. We agreed with them, that but for the sunshine we would all have died. On several occasions, we found boys with smallpox scabs still peeling, riding with others on our boy's wagon or tricycle. We

washed the playthings with disinfectant immediately. But we had to trust to the sun to save us from the germs which had had time to attach themselves before the discovery was made.

In the rainy season one appreciates the sun, by its absence. After a few days of heavy clouds and rain, the village lanes are like pools, fed by the streams which trickle from open house-drains and privies. The smells which rise up to greet one are nauseating. A few days of bright sunshine clear the pathway and atmosphere. The streams still trickle but they dry up before they become objectionable.

In this discussion, however, we are more interested in the sun's light as a source, or producer of, Vitamin D. As far as we know, it is the villager's sole source of Vitamin D, except for a small amount which he may get from green leaves. I have heard Westerners inquire, "If sunshine is beneficial, then why aren't Indian children large and stronger than they are?" This is demanding too much of sunshine. It cannot be expected to correct all diet defects. I have heard American doctors reply, that in rural India sunlight does well the work which they look to it to do. If our village children depended upon diet alone for adequate supplies of calcium and phosphorus, and for proper mobilization of the supplies, cases of rickets would be much more general and extreme than they are. I have found no definite records, beyond that of the work of Dr. Hutchinson and Dr. Shah. "A recent study of rickets in India by Hutchinson and Shah is clearly illustrative of the preventive role of sunlight. Surely there should be no rickets in India. Yet the infants of the top caste Hindus almost always develop extremely severe rickets. Owing to the religious custom of 'purdah,' which compels their mothers to live beyond the public gaze, these infants are practically never taken out of dusky rooms. In contrast the infants of Hindu laborers who cannot afford too expensive a religious detail practically never develop rickets. The women work with the men in the fields and leave their infants along-side in the sunlight. The rickets preventive action of sunlight is here particularly clear cut, since in both instances the dietaries of the mothers almost entirely lack the food-stuffs which contain the substance D." (16).

In Karimpur, custom co-operates with nature, in supplying sunshine to all castes. The women live and work in roofless courts. A few of these courtyard admit little sun in the winter months, but even they are better than stuffy rooms. Babies of all castes creep around naked during nine months of the year, and during the remaining three months they wear abbreviated cotton skirts. The children work in the fields or play in the lanes in scanty clothes which grow scantier with increasing heat. No one wears stockings, and few wear shoes. Craftsmen, instead of working in shops or work-rooms, carry on their crafts in village lanes or in open courtyards. The washerman, assisted by his whole family works beside a pond near our grove, not in a dark basement. Every one lives in the sunlight. And the sunshine blesses them. We have no cases of severe rickets in the village.

(16) See References.

Some of the attitudes of our people toward food are expressed graphically in sayings and proverbs. These are an expression of their experience with food. Some of them are revealing enough to be included in this study of their practices. The rhythm of the lines is lost in translation.

"Juar (great millet) is my mother and makes my cheeks swell like raised sweet-cakes. Bajra (spiked millet) is my brother and restores my wasted form."

"Whoever eats 'mung' pulse daily, becomes flatulent and drowsy."

"Don't call me 'arhar' (pigeon pea). My name is dear maiden. When all other grains are gone you come fumbling after me. Don't call me 'arhar'! My name is dear maiden. Two cakes of me are as filling as sixteen of other grains."

"Arhar with dried mango and an ounce of 'ghi' makes a dish for the king."

"Rice is good, but split peas are my life."

"Everything is false in the world, save pulse and bread."

"Eat bitter melons in September, radishes in August, and raw sugar in April—this is the way to spend your money and buy illness."

"Two things agree with a man—his own wife, and plain toasted cakes and pulse."

"Two things bring pain—'puris' (cakes fried in deep fat) and strange women."

V—VALUE OF FOODS NOW IN USE

The scientific study of food in India seems to have originated in the planning of diets for prisoners. In 1880, Surgeon-Major T. R. Lewis in his annual report points out a phase of the vegetarian diet of our people, which more recent students of nutrition have emphasized:

"That chemical analysis, however exhaustive, can only afford such information as will enable a proximate estimation to be formed of the nutritive value of any food seeing that it is not only what nutriment a particular food-stuff contains that is of moment, but also what portion of it can readily be digested and assimilated by the body. In a diet composed entirely of vegetable substances, the quality of the cooking is of much more importance than it is in animal food dietaries, seeing that a large proportion of nutriment contained in cereals and pulses is enclosed in extremely resistant, indigestible envelopes, which if not effectually disposed of by proper cooking defeat all attempts on the part of the digestive organs to profit by the food . . . . . . In some cases, however, the excess of nitrogenous elements is given in the form of parched, or otherwise imperfectly cooked grain, so that it is probable that a large proportion of the contained nutriment will not be assimilated. On several grounds, therefore the addition of undue proportion of pulses—and especially ill-cooked pulses—is a doubtful advantage, and may be even injurious." (17).

The most outstanding contributions in the study of jail dietaries were those made by Major D. McCay, of the Medical College, Calcutta. His first investigations were in Bengal, but it is his investigations into the jail dietaries of the United Provinces in which we are particularly interested. His statement of the jail dietaries in use in 1910 is useful in a consideration of diets of North India.

"The diet scales for adult native prisoners on hard labour consist of 1 lb. 12 oz. of a cereal pulse combination, 2 oz. of 'dal', 6 oz. of vegetables with salt, a little oil and chilli. The cereal pulse combination is invariably made up according to the subjoined table:

Combination diet	Principal		Adjuvant		Total
	Grain	Quantity	Grain	Quantity	
A . .	Wheat	1 lb. 6 oz. . .	Barley . .	6 oz.	28 oz.
B . .	Spiked millet . .	1 lb. 8 oz. . .	Pulse . .	4 oz.	28 oz.
C . .	Maize	1 lb. 8 oz. . .	Pulse . .	4 oz.	28 oz.
D . .	Millet	1 lb. 7 oz. . .	Pulse . .	5 oz.	28 oz.
E . .	Wheat	1 lb. 7 oz. . .	Gram . .	5 oz.	28 oz.
F . .	Great millet . .	1 lb. 6 oz. . .	Pulse . .	6 oz.	28 oz.
G . .	Barley	1 lb. 6 oz. . .	Wheat . .	6 oz.	28 oz.
H . .	Rice	1 lb. 4½ oz. . .	Wheat . .	7½ oz.	28 oz.

"Any two of the above may be combined by taking half of each principal and half of each adjuvant; thus $\frac{B+C}{2}$ will give spiked millet 12 oz. + maize 12 oz. + pulse 4 oz. = 28, or $\frac{A+C}{2}$ will give wheat 11 oz. + barley 14 oz. + pulse 3 oz. = 28.

"These are the official diet scales as sanctioned in the Jail Code, but in practice they are to a large extent ignored. The only diet commonly in use is Diet E of the above table; in fact it is the only one given in the majority of the jails all over the Province. During the cold weather months great millet, spiked millet, and barley are sometimes made use of, but hardly ever in the quantities laid down. The different superintendents give their own combinations of these food-stuffs with wheat and pulse, which are usually very different from the diets officially sanctioned.

(17) See References.

"Rice has been very rarely used in the United Provinces. As it is only grown to a limited extent, the price is prohibitive. It was, however some years ago used in two district jails, close to the borders of Bengal, but an outbreak of Beri-Beri in both of these caused it to be discontinued and its use has never been revived.

" 'Marua' (millet) is never given at all; in fact, we failed to obtain samples even for analysis from the different jails, where investigations were carried out.

"Maize is seldom, if ever used: why this is so we do not understand as it is a very nutritious food-material and certainly superior to some of those in use.

"The pulses made use of in the United Provinces are principally 'arhar dal' (pigeon pea) and 'urd dal.' It would appear from the above table gram 'dal' is not classed as a pulse, but this is mistake as gram 'dal' belongs to the pulses.

"For at least nine months in the year Diet E, i.e.—

Wheat	1 lb. 7 oz.
Gram	5 oz.
Arhar dal (pigeon pea)	2 oz.
Vegetables	3 oz.
Salt	150 grains.
Oil	9.08 grams.
Condiments	2 oz.

is given to the exclusion of all others." (18)

The diet now in use in our Mainpuri District Jail is practically what McCay recommended as a result of his investigatons.

In jail, the prisoners have a cereal, a pulse, and a vegetable daily. Our village people are glad if they can have a pulse or a vegetable with their cereal bread. They rarely have both on the same day. And sometimes they have neither, and eat salt with their bread. But the villager spends his time in the fields where he may snip off the green tips of plants or roast a handful of grain. The prisoner's fare is exactly that which is recorded. The farmer's is very likely not exactly what we have recorded.

McCay has some interesting comments on the contents of jail diets as compared with diets of the province outside the jail.

"We may, therefore, conclude this consideration of the pulses of these diet scales, by stating that they are present in quantities much in excess of what is required, and in far greater abundance than the people of the Province can afford, or wish to have. Two and a half chittacks or five ounces is the maximum amount of pulse that should enter into any diet, and, if gram is to be given it should be properly cooked, not made use of as parched gram, and it should never be the only pulse in the composition of the diet. The superiority of 'arhar dal' (pigeon pea) and the fact that it is the favourite form of pulse with natives of the United Provinces should ensure that this pulse will be used in all diets to as great an extent as possible. 'Urd dal' being more suitable than other forms in the preparation of 'bajra' (spiked millet) and 'juar' (great millet) for consumption, this 'dal' should be used in diets into the composition of which those cereals enter. One chittack (2 ounces) of 'urd dal' will be found amply sufficient in the cooking of the quantities of 'juar' or 'bajra' recommended in new dietaries." (19).

"Diet C in which the principal is 'makka' or maize, we have not investigated. It is never used, so far as we could gather, in the dietaries of the prisoners. Maize we found in Bengal was a very good food-material although not very palatable as prepared in Bengal Jails. It is not suitable alone for baking into bread or 'chapatti,' but is very good when mixed with wheat or prepared as porridge. We do not think it suitable as a principal, as in Diet C, but see no reason why maize should

(18), (19) See References.

Diet used in the Mainpuri Jail, 1928

—	Bread	Dal (split pulse)		Parched gram	Rice instead of ata	Vege-tables	Mustard oil	Salt	Chilies	Tur-meric	Dried mango
		With bread	With rice								
Labouring	24 oz.*	2 oz. ‡	4 oz.	4 oz.	16 oz. (48 oz. if cooked).	8 oz.	8 gr.	9 gr.	1 gr.	1 gr.	70 gr.
Non-labouring ..	20 oz. †	2 oz. ‡	4 oz.	None	12 oz. (36 oz. cooked.)	8 oz.	8 gr.	9 gr.	1 gr.	1 gr.	70 gr.

*November to March, 16 oz. spiked millet, 8 oz. wheat—daily.
April to November, 16 oz. wheat, 8 oz. gram—daily.
†November to March, $13\frac{1}{3}$ oz. millet $6\frac{2}{3}$ oz. wheat—daily.
April to November, $13\frac{1}{3}$ oz. wheat, $6\frac{2}{3}$ oz. gram—daily.
‡November to March—5 days: 2 oz. arhar (pigeon pea).
2 days : 2 oz. mung or urd.
April to November—7 days : 2 oz. arhar (pigeon pea).

not be given as a substitute for part of the wheat in dietaries. Why it should never be given in the jails of the United Provinces is difficult to understand, as, next to wheat, maize is the best cereal on the list. It is used during its season fairly largely by the inhabitants of the province, and the average crop being up to one million tons, there cannot be any great scarcity of this food to enhance its price. We are strongly of the opinion that maize has been neglected unjustly, and that, if given as we suggest, mixed with wheat, it would be found quite satisfactory." (20)

"Judging from inquiries we have made, wheat is the food of the higher and middle classes and a luxury to the poorer. In times of scarcity or famine, when wheat, gram and 'juar' are practically the same price, wheat is eaten largely by the people, but in ordinary times 'bajra' and 'juar' are the principal food-materials of the poorer classes and small cultivator.

"Makka or maize is also largely used as a food-material, barley and 'marua' not to so great an extent as the other cereals. 'Arhar dal' is the favourite form of pulse, and a small amount is partaken of daily.

"It is, therefore, only right and fair to the prisoners that these secondary food-materials, 'bajra,' 'juar,' 'makka,' barley and 'marua,' should not be denied them. While they are not suitable to be used alone, when given along with wheat, in the manner we have indicated in the diets suggested, they are exceedingly useful in varying the monotony of the wheat diet, and in providing food-materials to which the great mass of the prisoners are accustomed. (21).

". . . . from a physiological point of view it must be admitted that the dietaries at present in force, or any framed in future to maintain the same level are distinctly superior to those available for the great mass of the population, and that this will tend to place a premium on crime in periods of scarcity. This, however, is a problem with which we have no concern; we simply point out its bearing in passing and leave the present policy of the maintenance of the superiority of jail dietaries, over those possible to the same classes outside the walls of the jails, to be determined by the government of the country." (22)

We hope that our people will find an adequate diet without being obliged to go to jail to find it.

McCay's investigations led him to the conclusion that the protein factor determines the place of Indian races in the scale of physical efficiency. He traced all differences in physique to the different levels of nitrogenous interchange possible in the diet of wheat-eaters and the diet of rice-eaters. If he had made his investigations a few years later he would have modified his conclusions to include minerals and vitamins.

Since the studies of McCay there has been an increasing interest in the study of foods in India as elsewhere. But very little scientific work has been done. Colonel R. McCarrison has contributed more than anyone else through his experiments and through his efforts to use the results of his experiments in educating Indians in the possibilities of indigenous foods. He was a member of the Indian Medical Service until 1919 when he became Director of the Deficiency Diseases Inquiry, in the Pasteur Institute, Coonoor.

(20), (21), (22) See References.

One experiment which he carried on with two colonies of rats (20 in each colony) contrasted what he calls a "good diet" with a "bad diet." "One colony received a 'good diet,' designed to resemble that eaten by the Sikhs. It consisted of 'chapatties' made of whole wheat flour; uncooked, green vegetables, fresh fruits (tomatoes, etc.); sprouted gram (legumes); butter; fresh whole milk; and fresh meat occasionally." (23) Liberal quantities of each article were supplied so that the animals could select for themselves the amounts of each they cared to eat.

This diet is of interest to us, because all of the foods in it are available in our part of the country. Our village folk grow wheat, but they sell much of it. They do not grow as many green vegetables as they might, but at the same time they make use of every edible leaf within reach. They have plenty of gram, but they are accustomed to parching or cooking it. It would be easy for them to sprout it. They could grow tomatoes and oranges and lemons. Prejudice keeps them from growing tomatoes, and they have not tried growing citrus fruits, other than a few lime trees. Oranges are now grown in our area of the Province, and can be grown in Karimpur. They would be in season during the months when there are no mangoes. The village folk might have butter, but they clarify it all to make "ghi." The same is true of milk. There is milk in almost every home and some families drink it. But in most households the milk is heated and churned to be made into "ghi." As for meat, a few eat it now. The meat at present sold is very inferior, coming from old, decrepit or diseased animals. It is a poor recommendation for meat-eating.

Colonel McCarrison's "poor diet" consisted of foods eaten by any Western people of the poorer classes—white bread, cooked vegetables, a cocoanut oil margarine, canned meat and jam, with preservatives, and tea, with milk and sugar.

The experiment lasted six months, during which time all of the rats were given equally good care. They all had a two-hour sun bath daily. During the six months, three rats out of the 20 on the "good diet" died, one of them from injury. Nine of the 20 rats on the "poor diet" died. Three of these were killed and eaten by their fellows. After this, the rats of the ill-fed colony were separated every night and a small quantity of fresh vegetables was given three times a week. The other six died from broncho-pneumonia. There were 20 litters of rats born in the well-fed colony, and all of the 134 born were reared to maturity. In the ill-fed colony, two litters were born, one of seven and one of four rats. Two of these eleven died and the others were eaten before they could be removed.

The aggregate body weight in each colony was 2,540 grams at the start. At the end of the experiment, the aggregate weight of the "well-fed" colony (17 rats) was 3,170 grams, whereas that of the eleven survivors of the ill-fed colony was 1,300 grams.

Colonel McCarrison's conclusions are:

"Not only does the former (good diet) promote physical efficiency and health but the latter (poor diet) gives rise to stunting of growth, to physical inefficiency, and often-times to disease. The maladies of which the bad diet is so apt to lay the foundation are lung-diseases and gastro-intestinal disease." (24)

(23), (24) See References.

This last statement is based on his post mortem examinations.

Our people have the symptoms of the bad diet, while the good diet is within their reach. Experience has taught them much. But Science can add what experience has evidently missed. Few of them can read and those few see no newspapers or journals. The contributions of Science have no way of reaching them as yet. With its help they will be enabled to build up stronger bodies, without the need of importing new foods. With the raw materials already available, they have a better selection of foods than people in the West who are not as poor as they.

An article by Colonel McCarrison which appeared in "The Practitioner" on "The Relation of Diet to the Physical Efficiency of Indian Races" (25) is of value in our study. It is worth quoting at length.

> "Few who have travelled far in India can have failed to notice the remarkable differences in physical efficiency of different Indian races. So great is the contrast between certain stalwart, vigorous, and resolute people of the North and certain poorly developed and toneless inhabitants of the South and East, that the question arises: Why should there be these great differences between one race and another? In attempting to answer it, I shall put aside such factors as climate, prolonged exposure to the actinic rays of the sun, peculiar religious customs and endemic diseases. For while it cannot be doubted that these play their part in determining the position of different Indian races in the scale of physical efficiency diet is the most important of the factors concerned. . . . .
>
> "The food materials available to the people of India . . . are mostly derived fom the vegetable kingdom. They include rice, wheat, barley, maize, millet, legumes, vegetables and fruit. For various reasons—of which locality, poverty, religious scruples and habits are the chief—milk and milk products, eggs, and flesh meat enter little, if at all, into the diet of great masses of the people. The use of these commodities is confined, as a general rule, to the better classes and to certain races in Rajputana, the Punjab, Northern India, and the West Coast. The staple food of the masses thus consists of 'those parts of plants which have the function of storage tissues' (McCollum), viz., cereals and legumes. 'These are deficient in at least three dietary factors. All contain protein of relatively poor quality; all contain too little of certain mineral elements, especially calcium, sodium, and chlorine and all are deficient in fat-soluable vitamin A. It is true that the diet is supplemented with vegetables and fruits, but these are not eaten in sufficient quantity to compensate for the defects of the cereals and legumes. For these reasons the diet of many millions of people in India is an incomplete one which 'does not contain all the complexes necessary for the construction of living protoplasm' (McCollum). Now it is, to a large extent, in proportion to the way in which the defects of what may be called 'the basal diet' of the people of India are made good by the use of other foods containing more suitable protein, more of the essential mineral elements, and more vitamins, that the physical development and well-being of the different races of India depend.
>
> "The least satisfactory of all the diets in common use in India is that consisting of rice, 'dal' (legumes), vegetables and condiments. This diet is used by millions of people in Bengal, Madras, and elsewhere; and it is these who exhibit the lowest grade of physical efficiency and health."

We need not follow in detail, as it does not apply to our section of the country.

> "If now it be found that the diet of other races is such as corrects some or all of the five faults pertaining to the diet of rice and legumes, then, other things being equal, the better diet ought to be associated with a higher grade of physical efficiency in the races using it; this is precisely what we find. For when we pass from the rice and legume eaters of Lower Bengal to the wheat and legume eaters of the United Provinces—climate and other factors being practically the same in both localities—we see that the latter are 'better developed physically, more capable of hard work, hardier and more alive than the average resident of Bengal of the same class" (McCay). The reasons for this are that wheat provides a protein of better quality than rice; the composition of the diet admits of the absorption of a larger amount of protein, of the attainment in short of a higher level of nitrogenous interchange (McCay); there is not the same ingestion of carbohydrates nor the same tendency to gastro-intestinal disturbance; the deficiency

(25) See References.

of mineral elements is not so great, and the diet is, in general, richer in vitamin B. It is, however, faulty in regard to the quality of its protein and to its content of mineral essentials and of vitamin A; and since its users do not, as a general rule, supplement it with a sufficiency of other foods, rich in those elements and complexes in which it is poor, they lag behind, in physical development and well-being those races that do."

This describes the people of Karimpur. They are better developed than those of the south, but they have not reached the degree of physical efficiency attained by the races further north, whom McCarrison proceeds to describe.

"The high degree of physical efficiency of the Sikhs is attained on a diet of wholemeal bread, legume seeds, tubers and roots, vegetables and clarified butter, supplemented with liberal amounts of cow's, buffalo's or goat's milk (whole milk, buttermilk and curds). Beef is never eaten by them, but goat's flesh, mutton and game are eaten occasionally, although not in large quantities. In Sikh regiments, for instance, a pound of meat is eaten by each man two or three times a month, while 16 ounces of milk are taken daily. In their own homes much larger quantities of milk are used than is possible in regimental life. It is to be noted that milk and milk products are constant constituents of their food, other animal foods being regarded more as a luxury than as a necessity. Their children are breast-fed for two and a half years, the mother's milk being supplemented with diluted cow's or buffalo's or goat's milk during the later months of lactation; thereafter they are given liberal amounts of milk and are gradually brought on to the diet in use by their elders. The Sikhs use vegetables freely, but they do not eat fruit to the same extent as certain hill people whose climate is more suited to its cultivation.

"The food of the Pathans is much the same as the Sikhs, but they eat more meat and less legumes. They have the advantage of a better climate and more fruit and nuts are available for their use—mulberries, walnuts, etc.

"The people of Hunza make less use of meat than either the Sikhs or the Pathans. Their food is much the same as that of the Sikhs but less rich in milk, their stock being confined to goats. They are, however, great fruit-eaters, especially of apricots and mulberries. They use apricots and mulberries in both the fresh and dry state, drying sufficient of their rich harvest of them for use throughout the autumn and winter months. Dried mulberries are mixed with their wholemeal flour and made into cakes which form their staple article of diet. Meat is a luxury used only on special occasions. These people are unsurpassed by any Indian race in perfection of physique; they are long lived, vigorous in youth and age, capable of great endurance and enjoy a remarkable freedom from disease in general. To see a man of this race throw off his scanty garments and plunge into a glacier-fed river in the middle of winter is to realize that enforced restriction to the unsophisticated foods of nature—provided these be of the right kind—is no bar to the attainment of perfecion of physique.

"The diet of these three races—the Sikhs, the Pathans and the people of Hunza—provides an interesting example in man of the accuracy of the conclusions drawn by McCollum as a result of his extensive inquiry into the kinds of diets which succeed best in nutrition of animals. Putting aside the carnivorous type of diet on which satisfactory nutrition can be maintained there are two other types which he has found to be successful; (1) the seed, tuber, root and muscle type of diet which is supplemented with liberal amounts of leafy vegetables and or fruit; and (2) the type of diet derived from cereals, legume seeds, tubers, fleshy roots, with or without meat, supplemented with liberal amounts of milk—'milk being so constituted as to make good all the deficiencies of these classes of foods.' The diet of the Sikhs is practically identical with the latter type; that of the Pathans with the former; while that of the people of Hunza is a happy combination of 'the storage parts of plants,' leafy vegetables, fruit and milk, which gives, perhaps, the best result of all.

"So much then, for the relationship of diet to the physical development of the Indian races. There remains now to consider, very briefly, the extent to which their diets predispose them to disease or secure their freedom from it. We have seen that the great mass of the people of Bengal and Madras live on a rice-and-legume diet having at least five faults. Associated with these faults we find in Bengalis and Madrasis an unusual susceptibility to infection, a proneness to gastro-intestinal diseases—notably diarrhoea and dysentery—and a marked tendency to certain deficiency diseases—beri-beri, malnutritional oedemas, epidemic dropsy, and xerophalmia, which are not exhibited by races whose diet has not these faults. In regard to the proven effect of such food in lowering the natural resistance to infection, it is to be regretted that in India, as elsewhere, epidemiological inquiries have not kept pace with those in the laboratory. But in this connexion it may be remarked that the much higher incidence of leprosy in the South West, and

East of India than in the North has probably a nutritional basis. The high incidence of dysentery in the jails of Bengal as compared with its low incidence in those of the Punjab is another example of the same kind.

"Contrast now with these morbid effects of food having the faults above referred to—faults present in some degree in many dietaries at Home as well as in India—the state of health of the people of Munza who combine their foodstuffs so happily. With them resistance to infection is remarkable: anthrax, for example, does no more than produce a malignant pustule, while septicaemia is its common consequences in those less resistant to infection. Gastro-intestinal complaints—dyspepsia, gastric and duodenal ulcers, colitis and appendicitis—are as uncommon amongst them as they are common elsewhere. Even cancer is so rare that in nine years' practice I never came across a case of it. It may be that their seclusion or the mountain barriers which separate them from the rest of Asia has kept them free of many diseases carried by infected persons, but there can be no doubt that their freedom from disease is largely due to the food they eat and the health-giving life they lead in a bracing climate."

After this clear picture of MacCarrison's of the possible range of diets from foods grown in India, it will be of interest to observe the foods available in our particular area. The following table is a summary of the Food Sources discussed in Chapter I.

References used in identifying the products were:

(*a*) "The Commercial Products of India" by Sir George Watt (Published under the authority of His Majesty's Secretary of State for India in Council). John Murray, London.

(*b*) "Food Grains of India", by A. H. Church. Chapman and Hall, London.

(*c*) "Flora of the Upper Gangetic Plain", by J. F. Duthie.

When names were too local to be found in any of these, specimens were sent to Winfield Dudgeon, PH.D., Botany, of Ewing Christian College, Allahabad, who identified them for us.

Foods available in Karimpur by months

Names			Sources	When available											
English	Local	Botanical		Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan	Feb.	Mar.
Cereals															
Wheat ..	Gehun ..	Triticum vulgare ..	Own fields or other fields of village.	×	×	×	×	×	×	×	×	×	×	×	×
Maize	Makka ..	Zea mays ..	Fields of village	..	..	..	..	..	×	×	×	×	×	×	×
Rice	Dhan ..	Oryza sativa ..	Ditto	×	×	×	×	×	×	×	×	×	×	×	×
Millet	Marua ..	Eleusine coracana ..	Ditto	..	..	..	..	..	×	×	..	..	..	..	..
Italian millet ..	Kakun ..	Setaria italica ..	Ditto	..	..	..	..	..	×	×	×	×	..	..	..
Wild millet ..	Dhuniya ..	Like marua ..	Grows wild	..	..	..	..	..	×	×	..	..	..	..	..
Little millet ..	Kutki ..	Panicum miliare ..	Fields of village	..	..	..	..	..	..	..	×	×	×	..	..
Spiked millet ..	Bajra ..	Pennisetum typhoideum	Ditto	..	..	..	..	..	..	..	×	×	×	×	×
Poor man's millet	Sama ..	Panicum colonum ..	Ditto	..	..	..	..	..	..	×	×	..	..	..	..
Great millet ..	Juar ..	Sorghum vulgare ..	Ditto	..	..	..	..	..	..	..	×	×	×	×	×
Barley ..	Jao ..	Hordeum vulgare ..	Ditto	×	×	×	×	×	×	×	×	×	×	..	×
Wild rice ..	Pasai ..	May be variety of oryza coarctata.	Edges of tanks near village ..	..	..	..	..	..	..	..	×	×	..	..	..
Pulses															
Thick pea (gram) ..	Channa ..	Cicer arietinum ..	Fields of village	×	×	×	×	×	×	×	×	×	×	..	×
Cluster bean ..	Dararhi ..	Cyamopsis Psoralioides	Ditto	..	..	..	..	..	..	×	×	..	..	..	..
Cow pea ..	Ronsa ..	Vigna catjang ..	Ditto	..	..	..	..	..	..	×	×	..	..	..	..

As in the rest of the paper the spelling is reproduced exactly as in the original.

	Urd ..	Phaseolus mungo* ..	Ditto	×	×	×	×	×	..	..	×̲	×̲	×̲	×̲	×̲
	Mung ..	Phaseolus radiutus* ..	Ditto	×	×	×	×	×	..	..	×̲	×̲	×̲	×̲	×̲
Aconite Bean ..	Moth ..	Phaseolus aconitifolius	Ditto	..	×	×	×	×	..	..	×̲	×̲	×̲	×̲	×̲
Field pea ..	Mattar ..	Pisum arvense ..	Ditto	×̲	×	×	×	..	..	..	..	..	..	..	×̲
Pigeon pea ..	Arhar ..	Cajanus indicus ..	Ditto	×	×	×	×	×	×	×	×̲	×̲	×̲	×̲	×̲
Variety of pea ..	Tipakua mattar.	..	Ditto	×	..	..	..	..	..	..	..	..	..	..	×
String bean ..	Sem ..	Canavalia ensiformis ..	Local vegetable growers and those of other villages.	×̲	..	..	..	..	..	×	×	×	×̲	×̲	×̲
Vegetables															
Egg plant ..	Bangan ..	Solanum melongena ..	Local vegetable growers, near by villages Mainpuri bazar.	×̲	×	×	×̲	..	..	×	×	×̲	×̲	×̲	..
Variety of pumpkin	Lauka ..	Cucurbita pepo ..	Local vegetable growers, near by villages, Mainpuri.	×	×	×	×	×	..	..	..	..	..	..	×
Form of watermelon	Kalinda ..	Citrullus vulgaris ..	Near by villages	×	..	..	..	..	..	..	..	..	..	..	..
Melon like cucumber	Kakari ..	Cucumis utilissimus ..	Local vegetable growers and near by villages.	..	×	×	×	..	..	..	..	..	..	..	..
Onions	Piaz ..	Allium cepa ..	Other villages	×	×	×	×	..	..	..	..	..	..	..	..
Egypt. arum dasheen	Ghuian ..	Colocasia antiquorum ..	Own fields or Mainpuri ..	×	×	×	×	×	..	..	..	..	..	..	×
Leaves of arum ..	Ghuian ..	Colocasia antiquorum ..	Own fields or Mainpuri ..	..	..	..	..	..	×	×	×	..	..	..	..
Gourd	Lauki ..	Lagenaria vulgaris ..	Local vegetable growers or Mainpuri.	×̲	×̲	×	×	×	..	..	..	..	..	..	×̲

*These two reversed by Roxburgh.
×̲ Available in large amounts.
× Available in lesser amounts.

Foods available in Karimpur by months—(continued)

English	Names: Local	Names: Botanical	Sources	When available: Apl.	May	June	July	Aug.	S p.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Vegetables—(concld.)															
Bitter melon ..	Karela ..	Momordica charantia ..	Local fields, little from Mainpuri.	..	..	×	×	×	×	..	..	..	..	..	..
Okra	Bhindi ..	Hibiscus esculentus ..	Own fields. Grown with cotton.	..	..	..	×	×	×	×	..	..	..	..	..
Cucumber ..	Khira ..	Cucumis sativus ..	Own fields	..	..	..	..	×	×	×	..	..	..	..	..
Kind of gourd ..	Turayan ..	Luffa acutangula	Own fields with maize. Local vegetable growers.		..	..	..	×	×	×	×	..	..	..	..
Mushrooms ..	Kathpal ..	Agaricus campestris(?) ..	In fields	..	..	..	..	×	..	..	..	..	..	..	..
Melon like cucumber	Kacheria ..	Cucumis melo var. mamordica.	In cotton or maize fields ..	..	..	..	..	×	×	×	..	..	..	..	..
Related to cucumber	Sendha ..	Cucumis trigonis(?) ..	Local vegetable growers ..	..	..	..	..	..	×	×	..	..	..	..	..
Like cucumber ..	Arui Kacheria	Like Kacheria. Seeds not bitter.	Ditto ..	..	..	..	..	..	×	×	..	..	..	..	..
Variety of yam ..	Ratalu ..	Dioscorea bulbifera, var. pulchella.	Fields of village, little from Mainpuri.	..	..	..	..	..	..	×	×	..	..	..	..
Cauliflower ..	Phulgobi ..	Brassica cleracea var. Botrytis.	Vegetable growers of other villages.	..	..	..	..	..	..	..	×	×	×	×	..
Radishes ..	Muli ..	Raphanus sativus ..	Local vegetable growers (pickled after December).	..	..	..	..	..	..	..	×	×	×	×	..

Potatoes ..	Aïu ..	Solanum tuberosum ..	Own fields and vegetable growers.	×	×	..	..	..	..	..	..	×	×	×	×
Horse radish ..	Senjna ..	Moringa pterygosperma ..	Own fields (pickled) ..	×	×	..	..	..	..	..	..	×	×	×	×
Carrots	Gajar ..	Daucus carota ..	Local vegetable growers (pickled March-April).	×	..	..	..	..	..	..	..	×	×	×	×
Radish seed pods ..	Muli ki phali	(*See* radish)	Local vegetable growers ..	..	..	..	..	..	..	..	..	×	..	..	..
Sweet potatoes ..	Shakkarqand	Ipomoea batatas ..	Vegetable growers and own fields.	..	..	..	..	..	..	..	..	×	×	×	×
Cabbage	Gantor Band Gobi.	Brassica cleracea, variety capitata.	Mainpuri	×	..	..	..	..	..	..	..	..	..	..	×
Buds of Khata labhera.	Labhera ka bor.	Cordia myxa	Locally and other villages ..	×	×	..	..	..	..	..	..	..	..	..	×
Buds of kachnar ..	Kachnar ..	Bauhania variegata ..	Locally	..	..	..	..	..	..	..	..	..	..	..	×
Leafy vegetables															
Wild potherb ..	Nari ..	Ipomoea aquatica ..	Wild in ponds near village ..	..	..	..	×	×	×	×	..	..	..	..	..
	Paintiya ..	(Unable to locate) ..	Wild leaves spread on ground.	..	..	..	..	×	×	×	..	..	..	..	..
A Wild potherb ..	Lissua ..	Triumfetta pilosa(?) ..	Wild in uncultivated areas ..	..	..	..	..	×	×	×	..	..	..	..	..
Potherb	Chaunrai ..	Amaranthus viridis ..	Wild in fields	..	..	..	..	×	×	×	..	..	..	..	..
Radish top ..	Muli ki patti	(*See* radish)	Local vegetable growers ..	..	..	..	..	..	×	×	..	..	..	..	..
White goose-foot ..	Batua ..	Chenopodium album ..	In wheat and barley fields ..	..	..	..	..	..	..	..	×	×	×	..	..
Tops of pea vines ..	Mattar ki patti	(*See* peas)	Fields of village. (Dried April—July).	×	×	×	×	..	..	..	×	×	×	×	×
Gram tops ..	Channa ki patti.	(*See* chick-pea) (gram) ..	Local fields. (Dried April—July).	×	×	×	×	..	..	..	..	×	×	×	×

Foods available in Karimpur, by months—(continued)

English	Name: Local	Name: Botanical	Sources	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Leafy vegetables—(*concld.*)															
Chard	Palak ..	Beta vulgaris ..	Local vegetable growers and those of Mainpuri.	..	..	..	..	..	..	..	..	×	×	..	..
Mustard tops ..	Karari ..	Brassica campestris ..	Local fields. (Dried March—July).	×	×	×	×	..	..	..	..	×	×	×	×
Fenugreek ..	Methi ..	Trigonella foenum-graecum.	Local fields. (Dried April—July).	×	×	×	×	..	..	..	..	×	×	×	×
Dill	Soya ..	Peucedanum graveolens ..	Usually grown with palak ..	..	..	..	..	..	..	..	..	×	×	×	×
Fruit															
Green mangoes ..	Am ..	Mangifera indica ..	Groves, along roadside, around wells. (Pickled or dried after July.)	×	×	×	×	×	×	×	×	×	×	×	..
Wild figs ..	Gular ..	Ficus glomerata ..	Groves of village	×	×	×	×	..	..	..	..	..	..	..	..
Mahua blossoms ..	Mahua ke phul.	Bassia latifolia ..	Ditto	×	×	×	..	..	..	..	..	..	..	..	..
	Bel ..	Aegle marmelos ..	Ditto	×	×	×	×	×	..	..	..	..	..	..	×
Berries of peepal ..	Pipali ..	Ficus religiosa ..	Ditto	×	×	×	×	..	..	..	..	..	..	..	..
Sweet melon. (Like musk melon.)	Kharbuz ..	Cucumis melo ..	Locally and other villages ..	×	×	×	×	..	..	..	..	..	..	..	..

Jack fruit	Kathal	Artocarpus integrifolia	Groves of the village	..	..	×	..	..	..	..	..	..	..	..	..
Guava	Amrud	Psidium guyava	Few in village. Other villages	..	..	×	×	×	×	×	×	×	×	×	..
Date	Khajur	Phoenix sylvestris	Near village	..	..	×	×	×	×	×	..	..	..	..	..
Date	Chuara	Phoenix dactylifera	Ditto	..	..	×	×	×	×	×	..	..	..	..	..
Margosa berries	Nimori	Melia azadirachta	Trees around village	..	..	×	×	..	..	..	..	..	..	..	..
Banyan	Bargat	Ficus bengalensis	Ditto	..	×	×	×	..	..	..	..	..	..	..	..
Like a plum	Jaman	Eugenia jambolana	Ditto	..	..	..	×	×	..	..	..	..	..	..	..
Pomegranate	Anar	Punica granatum	Groves of village. From bazar	..	..	..	×	×	..	..	..	..	..	..	×
Berries of heens	Hins	Capparis sepiaria	Trees near village	..	..	..	..	×	×	×	..	..	..	..	..
Lime	Nimbu	Citrus acida	Groves of village—few, (Pickled December—April.)	×	..	..	..	..	..	..	×	×	×	×	×
Wood apple	Kait	Feronia elephantum	Groves of village	×	×	×	..	..	..	..	×	×	×	×	×
Wild plum	Jahrberi	Zizyphus rotundifolia	Around village	..	..	..	..	..	..	..	×	×	×	..	..
Tamarind pods	Imli	Tamarindus indica	Groves of village	×	×	×	..	..	..	..	..	..	..	..	×
Indian jujube	Ber	Zizyphus jujuba	Groves and fields	..	..	..	..	..	..	..	..	..	×	×	×
Like plums	Khata labhera	Cordia myxa	Local groves and those of other villages.	..	×	×	×	×	..	..	..	..	..	..	..
Like plums	Rai labhera	Cordia vestita	Chiefly from other villages	..	×	..	..	..	..	..	..	..	..	..	..
Plantain	Kela	Musa sapientum	Groves of village and Mainpuri.	..	×	×	×	×	×	×	..	..	..	..	..
Water melon	Turbuza	Citrullus vulgaris	Local vegetable growers and those of other villages.	..	..	×	×	..	..	..	..	..	..	..	..

Foods available in Karimpur by months—(concluded)

English	Name: Local	Name: Botanical	Sources	When available: April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Other foods															
	Phapola ..	Nymphoce lotus ..	Grows in ponds near village ..	×	. .	. .	. .	. .	×	×	×	×	×	×	×
Water chestnut ..	Singhara ..	Trapa bispinosa ..	Peinds near village ..	. .	. .	. .	. .	. .	. .	×	×	. .	. .	. .	. .
Sugarcane ..	Ik ..	Saccharum officinarum ..	Fields of village	. .	. .	. .	. .	. .	. .	. .	×	×	×	×	×
Mustard	Sarson ..	Brassica campestris ..	Grows in fields with wheat, barley, or gram.	×	×	×	×	×	×	×	×	×	×	×	×
Rape	Lahi ..	Brassica napus. Var. dichotoma.	In fields, usually alone ..	×	×	×	×	×	×	×	×	×	×	×	×
Mustard	Duan ..	Eruca sativa	Groves as border, or mixed with barley.	×	×	×	×	×	×	×	×	×	×	×	×
Mustard	La or Rai ..	Brassica juncea ..	Border of wheat and barley fields.	×	×	×	×	×	×	×	×	×	×	×	×
Black and white sesamum.	Ti and Tilli	Sesamum indi um ..	In fields with millet or cotton..	. .	. .	. .	. .	. .	. .	. .	×	×	×	×	×
Mint	Podina ..	Mentha viridis ..	Court yards	×	×	×	×	×	×	×	×	×	×	×	×

The preceding record tells us what foods our village people eat. And the following diet records give us an idea of how much they eat. We cannot hope to arrive at accurate results, with the equipment of village homes and the preparation of illiterate village housewives. These two drawbacks we could have met. But custom rose up to complicate each step.

To get a representative picture of village food consumption, I thought that we should have records from at least twelve homes each representing a different standard. I could not rely upon the women of these homes to do the recording, as they were not accustomed to measuring their food, and they could not have kept any records of the measurements if they had made them. As was mentioned in connexion with Food Sources, measuring is a casual matter, and is usually comparative—one food balancing another. The two women who could write and whom I could have taught to do the measuring, were kept in strict seclusion within their own courtyards. I had lived in the village long enough to know that my interference in anything related to food would be most unwelcome, even among my best friends. I finally chose three Brahman boys to help in the project. They could write. They were still young enough to be acceptable in any of the homes, and their caste made them doubly welcome. They went into the project very seriously and importantly.

One of the many surprises I had in connexion with it, was the willingness of the women to let the boys write down figures which they themselves could not read. Village men, and still more, village women, have a great fear of written records. In their experience the only exact records have been those kept by Government clerks, rent collectors and grain and money-lenders. As a result they associate recorded figures with oppression. They become restrained at the sight of a note book and pencil. So I learned to make mental notes, to be written down after getting back to our tent. But with the boys, recording took on a different aspect. They flourished their pencils and paper—both rare in the village—and made a great fuss over their measurements and figures. And the women laughed and were willing to humour them. But before the second month was up, their old suspicions were aroused. Some one brought up the question which blocked us repeatedly. Why did we want such figures? They began to imagine that the quantities of food they ate might reveal their status in some way. And this discovery might in turn lead to an increase in taxation. To this road, all paths seemed to lead—fear of increased interest or taxation.

Also, I realized that within certain seasons, the diet is monotonous enough to make records for short periods satisfactory. We waited for a new set of field crops. But in waiting, we missed the wild herbs, and the rainy season vegetables. These may be found in the partial food records for August and September, appended to this chapter. We renewed our weighing and recording in November. One week was found enough to cover that season.

There were still other complications which added to the interest of record-keeping. In our village we have three distinct systems of weights, for those who

aspire to weighing. One is called "kachcha." According to it, one "ser" is 1.4 avoirdupois pounds. The second is called "pakka." According to it, one "ser" is 2.8 avoirdupois pounds. And a third is "sarcari" or "official" amounting to 2.12 pounds. We tried to keep each of our helpers to the system to which he was most accustomed. But they were apt to slip from one to another and back again, without noting the change. This required additional checking.

In the light of these possibilities of error, I make no claims for the dietaries beyond the fact that they are a seriously made estimate of foods eaten in village homes.

The next question we ask is—Do the amounts of these foods eaten meet the needs of the people who eat them. To estimate this, I figured the total daily food allowance necessary for each family, and compared this with the content of the foods eaten by the same family in one average day. The food allowance for each member of a family for a day is calculated according to the suggestions of Edith Hawley. (26). These are then totalled to give the need of the whole family for a day.

Hawley does not include iron. So I have based the allowance for adults on Sherman's "Chemistry of Foods," (27) and that for children is calculated from the amount suggested by Rose and others in a special study of iron intake and output of a girl 31 months old, weighing 31 pounds. They recommend that children two to three years of age receive at least 0.75 milligrams of iron per 100 calories. (28).

The needs of the pregnant women were calculated from figures given by Rose (29). Those of the nursing mother were calculated from suggestions made by Rose in "Feeding the Family. (30)."

(26), (27), (28), (29), (30) See References.

*Foods eaten by a Brahman family of Karimpur during one week of May, 1928**

Date	Cereal in bread	Parched cereal	Rice	Split pulse	Vegetables	Fruit	Milk butter-milk, or curd	Meat	Oil or ghee	Raw sugar or other sweet	Salt
May, 1928	lb. oz.			lb. oz.	lb. oz.		(Milk) qts		(Ghee) lb. oz	lb. oz.	
25	Wheat 7 0	..	..	Pigeon pea. 1 12	Cucumber 2 12	Mangoes 8	1½	..	..	5½	..
26	Wheat 3 8 Barley 3 8	..	..	..	Egg plant 2 2	Mangoes 2	1½	..	0 4	1 0	..
27	Wheat 3 8 Barley 3 8	..	..	Pigeon 1 6	Gram tops 0 12	Mangoes 10	1½	..	..	5½	..
28	Wheat 3 8 Barley 3 8	..	..	Pigeon pea. 1 6	Pumpkin 1 6	Muskmelon 4	1½	..	1 0	5½	..
29	Wheat 3 8 Barley 3 8	..	..	Gram 0 6½	Pumpkin 1 6	Mangoes 4	1½	..	..	6	..
30	Wheat 3 8 Barley 3 8	..	..	..	Pumpkin 2 2	Muskmelon 1	1½	..	0 6	5½	..
31	Wheat 3 8 Barley 3 8	..	..	..	Cucumber 0 8	Mangoes 6	1½	..	..	..	..
Total weight.	Wheat 28 0 Barley 21 0	.. ..	.. ..	Pigeon pea. 4 8 Gram .. 0 6½	Cucumber 3 4 Pumpkin 4 14 Egg plant 2 2 Gram tops 0 12	Mangoes 30 Muskmelon 5	10½	..	1 10	2 12	1 lb. (weekly total.)

*Three men (ages 47, 25, 20).
Two women (ages 17, 15).
One boy (age 9—brother of younger woman).
One infant (age 10 months).
One helper (age 12).

*Food eaten by a Brahman family of Karimpur during one week of November, 1928**

Date	Cereal in bread	Parched cereal	Rice	Split pulse	Vegetables	Fruit	Milk butter-milk	Meat	Oil or ghee	Pickles	Raw sugar or other sweets	Salt
November, 1928.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.				'Ghee' lb.oz.	oz.	lb. oz.	
6	Maize 8 6	Barley 0 3	..	Urd 2 2	Patato 1 6	..	..	..	0 3	3	0 5½	..
7	Maize 3 8 Wheat 4 5	Maize 0 3	..	Mung 1 6	Cauli-flower. 1 6	..	..	..	0 3	..	5½	..
8	Wheat 4 3	Maize 2 12	3 8	Pigeon pea. 1 6	..	..	..	..	..	..	..	..
9 (One hired man).	Wheat 8 6 Maize 2 2	..	..	..	Potato 2 12	..	..	..	..	..	0 5½	..
10	Maize 7 11	Barley 0 12	..	Pigeon pea. 1 6	..	..	..	..	1½	..	0 8	..
11	Wheat 10 8 (Special cakes for festival. Three lbs. given away).	..	..	..	Potato 4 3	..	..	..	2 8	3	1 6	..
12	Wheat 6 5	..	..	..	Potato 2 12 Mustard tops. 0 12	..	..	..	1 0	3 3	..	..
Total weights.	Wheat 33 9 Maize 21 11	Barley 0 15 Maize 2 15	3 8	Pigeon pea. 2 12 Urd 2 12 Mung 1 6	Patato 11 1 Cauli-flower 1 6 Mustard tops. 0 12	..	..	..	3 15½	12	2 14½	1 lb. (weekly total).

*Three men (ages 47, 25, 20).
Two women (ages, 17, 15).
One boy (age 9—brother of younger woman).
One infant (age 10 months).
One helper (age 12).

*Food eaten by a Carpenter Family of Karimpur during one week of May, 1928**

Date	Cereal in bread	Parched cereal	Rice	Split pulse	Vegetables	Fruit	Milk butter milk	Goat meat	Oil or ghee	Pickles	Raw sugar or other sweets	Salt
May, 1928	lb. oz.	lb. oz.		oz.	lb. oz.				oz.	oz.	oz.	
25	Wheat 2 7	..	..	Parched gram. 3	Pumpkin 2 0	Muskmelon 5	..	..	Mustard oil. 4	..	6	..
26	Barley 2 7 Wheat 2 7	..	..	..	..	Muskmelon 4	..	..	Mustard oil. 4	..	..	..
27	Barley 2 7 Barley 2 7	Barley 8	..	Pigeon Pea. 3	..	..	..	..	..	Mangoes 6	5½	..
28	Peas 2 7 Barley 2 7	Barley 8	..	..	Pumpkin 1 6	Mangoes 7	..	..	Mustard oil 4	..	..	..
29	Peas 2 7 Barley 2 7	..	..	..	Pumpkin 1 6	Watermelon 1	..	..	Mustard oil 4	..	..	..
30	Peas 2 7 Wheat 2 7	..	..	..	Pumpkin 1 6	Muskmelon 4	..	..	Mustard oil 4	..	..	..
31	Barley 2 7 Barley 2 7 Peas 2 7	Barley 12	..	..	Pumpkin 1 12	Mangoes 8	..	..	..	..	5½	..
Total weights	Wheat 7 5 Barley 17 1 Peas 9 12	Barley 1 12	..	Gram 3 Pigeon pea. 3	Pumpkin 7 14	Muskmelon 13 Watermelon 1 Mangoes 15	..	..	Mustard oil. 20	Mangoes 6	17	12 oz. (weekly total).

*Two men (ages 33, 24). | Three women (ages 50, 27, 20).
One girl (age 10). | One boy (age, 4).
One girl (age 3).

*Food eaten by a carpenter family of Karimpur during one week of November, 1928**

Date	Cereal in bread	Parched cereal	Rice	Split pulse	Vegetables	Fruit	Milk, butter-milk	Goat meat	Oil or ghee	Pickles	Raw sugar or other sweets	Salt
November, 1928.	lb. oz.	lb. oz.	lb.oz.	lb. oz.	lb. oz.		Butter milk qts.		lb. oz.	oz.	lb. oz.	
6	Maize 8 6	..	..	Pigeon pea 1 6	..	..	1	..	..	Mango 3	0 5½	..
7	Great millet 7 11	Maize 0 12	..	Pigeon pea 1 6	..	..	..	..	..	..	..	..
8	Maize 7 9	Barley 1 0	..	..	Radishes with tops 1 6	..	..	..	Mustard oil 1½	Mango 3	0 3	..
9	Maize 7 0	Barley 1 0	..	..	Egyptian arum 1 6	..	..	..	..	..	..	..
10	Great millet 7 11	..	Puffed rice 1 6	Pigeon pea 1 6	..	Guavas 5	1	..	..	..	..	..
11 Festival puris.	Wheat 9	..	..	..	Egyptian arum 2 12	..	1	..	Mustard oil 12	Mango 1½	0 12	..
12 More puris	Wheat 7 0	..	..	..	..	..	..	..	Ghee 1 6	Mango 1½	..	..
Total weights.	Maize 22 6 Wheat 16 0 Millet 15 6	Maize 0 12 Barley 2 0	Puffed rice 1 6	Pigeon pea 4 2	Radishes 1 6 Arum 4 2	Guaves 5	3	..	Mustard oil 13½ Ghee 1 6	Mango 9	1 4½	12 oz. weekly total).

*Two men (ages 33, 24). Three women (ages 50, 27, 20). One child (age 3) | One girl (age 10). One boy (age 4).

*Food eaten by an oil presser family of Karimpnr during one week of May, 1928**

Date	Cereal in bread	Parched cereal	Rice	Split pulse	Vegetables	Fruit	Milk, butter milk	Goat meat	Oil or "Ghee"	Pickle	Raw sugar or other sweets	Salt
May, 1928	lb. oz.	lb. oz.		lb. oz.	lb. oz.			lb. oz.	(Oil) oz.		oz.	
25	Wheat 2 12 Barley 2 12	..	..	..	..	..	..	1 6	3	..	..	..
26	Wheat 2 14 Barley 2 14	..	..	Pigeon pea 0 3	..	..	..	..	..	..	..	..
27	Wheat 1 14 Barley 1 14 Gram 1 14	..	..	Pigeon pea 0 3	..	..	..	..	..	..	..	..
28	Wheat 2 12 Barley 2 12	..	..	..	Gourd 1 6	Mangoes 18	..	..	2	..	12	..
29	..	Roasted barley 1 6	..	Parched gram 1 6	..	Watermelon 2	..	..	..	..	..	..
30	Wheat 1 14 Barley 1 14 Gram 1 14	..	..	Pigeon pea 0 3	..	Watermelon 1	..	..	..	..	..	..
31	Wheat 1 14 Barley 1 14 Gram 1 14	Roasted barley 0 12	..	Pigeon pea 3	..	Watermelon 2	..	0 12	2	..	..	..
Total weights.	Wheat 14 0 Barley 14 0 Gram 5 10	Roasted barley 2 2	..	Pigeon pea 0 12 Parched gram 1 6	Gourd 1 6	Watermelon 5 Mangoes 18	..	2 2	7	..	12	3 oz. (weekly total)

*One man (age 38). One woman (age 27).
One girl (age 11). One boy (age 6).
One boy (age 6 months).

*Food eaten by an oil presser family of Karimpur during one week of November, 1928**

Date	Cereal in bread	Parched cereal	Rice	Split pulse	Vegetables	Fruit	Milk, butter-milk	Goat meat	Oil or ghee	Pickles	Raw sugar or other sweet	Salt
November, 1928	lb. oz.	oz.		lb. oz.	lb. oz.		(Butter milk). Qt.		oz.	oz.	lbs.	oz.
6	Maize 2 12	..		Parched gram 0 12	Radishes with tops. 0 12		1		Mustard oils 1½	..	..	..
7	Maize 2 12	..	..	Pigeon pea 0 12	..	..	..	..	..	..	..	..
8	Maize 2 0	Roasted wheat 5½	..	Pigeon pea 0 12	..	..	..	..	..	..	0 2	..
9	Maize 4 3	..	..	..	..	..	..	..	..	..	..	..
10	Spiked millet 4 3	Parched corn. 5½	..	..	Spinach 1 6	..	1	..	..	Mangoes 2	..	..
11 (festival).	Wheat 5 9	..	..	Parched gram 0 12	Egyptian arum 2 0	..	..	..	Mustard oil 12 Ghee 12	..	1 0	..
12	Wheat 2 0 Maize 2 12	..	..	Urd 0 8	..	..	..	..	..	Radish 3	..	..
Total weights	Maize 14 7 Wheat 7 9 Spiked millet. 4 3	Parched corn 5½ Roasted wheat 5½	..	Pigeon pea 1 8 Parched gram 1 8 Urd 0 8	Radishes 0 12 Spinach 1 6 Arum 2 0	..	2		Mustard oil 13½ Ghee 12	Mangoes 2 Radish 3	1 2	3 (weekly total).

*One man (age 38).
One woman (age 27).
One boy (age 6 months).
One girl (age 11).
One boy (age 6).

*Food eaten by an outcaste family of Kari mpur during one week of May, 1928**

Date	Cereal in bread	Parched cereal	Rice	Split pulse	Vegetables	Fruit	Milk, butter, milk	Meat	Oil or "ghee"	Pickles	Raw sugar or other sweets	Salt
May, 1928	lb. oz.			lb. oz.	lb. oz.		(Butter-milk).	oz.		oz.		oz.
25	Wheat 2 12	..	..	..	Pumpkin 0 12	Mangoes 6	½ qt.	..	..	..	..	..
26	Wheat 1 6 Barley 1 6	..	..	..	..	Mangoes 4	..	..	..	3	..	..
27	Wheat 1 6 Barley 1 6	..	..	..	..	..	..	12	..	..	..	..
28	Wheat 1 6 Barley 1 6	..	..	Pigeon pea, 0 12	..	..	..	..	..	..	..	..
29	Wheat 1 6 Barley 1 6	..	..	Pigeon pea 0 12	..	Mangoes 6	..	..	..	..	..	..
30	Wheat 1 6 Barley 1 6	..	..	..	Pumpkin 1 6	..	..	..	..	..	..	..
31	Wheat 1 6 Barley 1 6	..	..	..	Pumpkin 1 6	Mangoes 4	..	..	..	..	..	..
Total weights.	Barley 8 4 Wheat 11 0	..	..	Pigeon pea 1 8	Pumpkin 3 8	Mangoes 20	½ qt.	12	..	3	..	4½ (weekly total).

*One man (age 22). One woman (age 50). One woman (age 18). One boy (age 3).

*Food eaten by an outcaste family of Karimpur during one week of November, 1928**

Date	Cereal in bread	Parched cereal	Rice	Split pulse	Vegetables	Fruit	Milk, butter-milk.	Oil or ghee	Pickles	Raw sugar or other sweets	Salt
November, 1928.	lb. oz.	oz.		lb. oz.	lb. oz.		(Butter-milk). qt.	lb. oz.	oz.	oz.	oz.
6	Great millet 2 12	..	..	Pigeon pea 0 8	..	..	1	..	Mango 1½	..	..
7	Great millet 2 12	Barley 5½	..	Pigeon pea 0 8	..	..	..	..	..	..	..
8	Maize 3 8	..	..	..	..	..	1	..	..	1½	..
9	Maize 3 2	..	..	Pigeon pea 0 12	..	..	..	..	Mango 1½	..	..
10	Maize 3 2	..	..	Pigeon pea 0 12	..	..	..	..	..	..	..
11 (festival)	Wheat 2 12	..	..	..	Radishes with tops 1 6	..	..	Mustard oil 0 12	Mango 3	8	..
12	Wheat 3 8	..	..	..	..	..	1	Mustard oil 0 12	Mango 3	3	..
Total weights.	Wheat 6 4 Maize 9 12 Great millet 5 8	Barley 5½	..	Pigeon pea 2 8	Radishes with tops 1 6	..	3	Mustard oil 1 8	Pickles 9	12½	5 (weekly total).

*One man (age 22).
One woman (age 50).
One woman (age 18).
One boy (age 3).

The content of the foods eaten had to be based on analyses of the same or similar foods in the West. I realize that their application to foods grown, stored and prepared in homes of North India, can only be an approximation. The food tables in Rose's Laboratory Manual, third edition, 1929, and Sherman's Chemistry of Foods, third edition, 1930, were my chief references, supplemented by Bulletins of the United States Department of Agriculture and of Hawaii.

The calories, carbohydrate, fat, protein, calcium, phorphorus and iron contained in the total amount of each separate food eaten by a family during the week were found. These constituents were then totalled (from all foods eaten during the week) and divided by seven, to get the daily average for the family.

These tables with their requirements based on the comparatively low weights of our village people, imply that the foods which they are getting are adequate, except in calcium. But as we compare their physique with that of the Sikhs, admired by McCarrison, we know that they are low in weight and height. A review of each food constituent may help explain the lack.

Calories—According to the figures estimated, calories are more than sufficient for the oil-presser family, and very nearly adequate for the others, except the carpenters. These calories come chiefly from carbohydrates and protein, which implies that an unusually large amount of both of these must be consumed. Their chief sources are cereals and pulses. The figures for cereals consumed are based on five-sixths of the quantity recorded as being taken out of the store-rooms by the women. We found in a number of experiments with toasted cakes that from

A comparison of nutritive needs with food consumption of a Brahman family in Karimpur

—	Calories	Weights in grams			
		Protein	Minerals		
			Ca.	P.	Fe.
Total amounts needed daily	16,609	422.7	4.600	6.972	.104
Total amounts consumed daily (May, 1928)	13,855	466.8	3.699	13.216	.144
Total amounts consumed daily (November, 1928).	16,865	440.66	2.227	11.539	.120

Estimated daily needs of individual members of family. Total need is based on these figures

—	Weight in lb.	Calories	Weights in grams			
			Protein	Minerals		
				Ca.	P.	Fe.
One man (age 47 years) ..	110	2,310	49·5	·550	·990	·015
One man (age 25 years) ..	105	2,205	47·3	·525	·945	·015
One man (age 20 years) ..	115	2,415	51·7	·575	1·035	·015
One woman (age 17 years) lactating.	90	2,530	68·0	·787	·970	·018
One woman (age 15 years) pregnant.	85	1,985	45·0	·675	·800	·018
One baby girl (age 10 months)	16	..	..	..	..	..
One boy (age 9 years) ..	54	1,944	70·2	·648	·972	·018
One helper (age 12 years) ..	70	3,220	91·0	·840	1·260	·015
Total ..	..	16,609	422·7	4·600	6·972	·104

A comparison of nutritive needs with food consumption of carpenter family of Karimpur

—	Calories	Weights in grams			
		Protein	Minerals		
			Ca.	P.	Fe.
Total amounts needed daily ..	13,230	366·9	4·075	6·725	·097
Total amounts consumed daily (May, 1928.)	7,838	297·3	1·534	7·118	·0924
Total amounts consumed daily (November, 1928.)	12,878	364·5	1·5209	7·005	·0771

Estimated daily needs of individual members of family. Total need is based on these figures

—	Weight in lbs.	Calories	Weights in grams			
			Protein	Minerals		
				Ca.	P.	Fe.
One man (age 33 years) ..	110	2,310	49·5	·550	·990	·015
One man (age 24 years) ..	105	2,205	47·3	·525	·945	·015
One woman (age 27 years) ..	90	1,890	40·5	·450	·810	·015
One woman (age 50 years) ..	85	1,785	38·3	·425	·760	·015
One woman (age 20 years) ..	95	1,995	42·8	·475	·855	·015
One boy (age 4 years) ..	30	630	42·0	·540	·750	·006
One girl (age 3 years) ..	25	525	35·0	·450	·625	·006
One girl (age 10 years) ..	55	1,890	71·5	·660	·990	·010
Total ..		13,230	366·9	4·075	6·725	·097

A comparison of nutritive need with food consumption of an oil pressure family of Karimpur

—	Calories	Weights in grams			
		Protein	Minerals		
			Ca.	P.	Fe.
Total amounts needed daily ..	6,606	196·4	2·148	3·420	·037
Total amounts consumed daily (May, 1928).	8,325	325·85	·993	8·399	·0942
Total amounts consumed daily (November, 1928).	7,479	231·14	1·795	6·441	·0658

Estimated daily needs of individual members of family. Total need is based on these figures

—	Weight in lbs.	Calories	Weights in grams			
			Protein	Minerals		
				Ca.	P.	Fe.
One man (age 38 years) ..	100	2,100	45·0	·500	·900	·015
One woman (age 27 years) ..	80	2,160	36·0	·400	·720	·015
One girl (age 11 years) ..	50	1,050	65·0	·600	·900	·010
One boy (age 6 years) ..	36	1,296	50·4	·048	·900	·009
One boy (age 6 months) ..	12	..	..	..	..	..
Total ..	..	6·606	196·4	2·148	3·420	·037

A comparison of nutritive needs with food consumption of an outcaste family of Karimpur

—	Calories	Weights in grams			
		Protein	Minerals		
			Ca.	P.	Fe.
Total amounts needed daily ..	6,816	162·5	1·868	3·165	·050·
Total amounts consumed daily (May, 1928).	4,468	170·19	·714	4·690	·039
Total amounts consumed daily (November, 1928).	5,985	180·8	·862	3·658	·0312

Estimated daily needs of individual members of family. Total need is based on these figures

—	Weight in lbs.	Colories	Weights in grams			
			Protein	Minerals		
One man (age 22 years) ..	105	2,205	47·3	·525	·945	·015
One woman (age 50 years) ..	85	1,785	38·3	·425	·760	·015
One woman (age 18 years) ..	90	1,890	40·5	·450	·810	·015
One boy (age 3 years) ..	26	936	36·4	·468	·650	·005
Total ..	..	6,816	162·5	1·868	3·165	·050

every three pounds of grain taken out to be used, eight ounces are lost in grinding and cleaning. The loss in the case of pulses was not recorded. In the Brahman home, the pulses are soaked and the husks removed, but in poorer homes, the whole pulse is usually cooked.

The daily average of carbohydrates recorded as having been eaten by our four village families are as follows:

Carbohydrates in dietaries of four Karimpur families

Family	Month	Daily average (grams)	Per cent. of total calories (daily average) in form of carbohydrates
Brahman	May	2,487.67 g.	72
	November	2,874.22	72
Carpenter	May	1,385.50	71
	November	2,397.38	75
Oil-presser	May	1,371.80	75
	November	1,311.60	70
Outcaste	May	868.4	78
	November	1,013.3	68

McCay in his jail investigations made a study of co-efficients of absorption of carbohydrates. His table is as follows:

Wheat	(23 oz.)	96.5 %	absorbed.
Barley	(23 oz.)	96.0 %	"
Great millet		97.8 %	"
Spiked millet		97.8 %	"
Gram	(5 oz.)	97.7 %	"
Pigeon pea		96.8 %	"

Of fats, McCay says, "We have made no investigations on the absorption of fats of the jail dietaries of the United Provinces. The quantity of fat in these diets is very small and did not appear of sufficient importance to warrant special enquiry." (31).

Our figures for the average daily amount of fats used are as follows:

(31) See References.

Fats in dietaries of four Karimpur families.

Family	Month	Daily average (grams)	Per cent. of total calories (daily average) in form of fats
Brahman	May	222.34	14
	November	239.56	15
Carpenter	May	110.95	13
	November	201.28	14
Oil-presser	May	86.50	9
	November	141.19	17
Outcaste	May	30.65	
	November	126.45	19

The larger amount consumed by all families in November is due to the advent of a special festival. Wheat and *ghee* were substracted from the original figures of the Brahman family, to allow for cakes distributed to dependants. A lesser amount of wheat and mustard oil was substracted from the figures given by the carpenter, as they too have begging callers at this time. But after these amounts have been deducted, the festival figures still stand high.

The Brahmans of the village are reputed as using more *ghee* than others. This may be accounted for by their comparative prosperity, and by the greater demand for "pakka" food among them. This is discussed under Food Practices.

In most proposed dietaries, the calories furnished by protein are listed separately, whereas those of fats and carbohydrates are lumped together. Lusk has collected standard dietaries, a study of which may be useful.

> "The 'standard' dietaries are given below, not because they are inflexible requirements in any sense of the word, but merely for the convenience of the reader. The individual standard will ever be controlled by climate, the amount and kind of mechanical effort, by appetite, purse and dietetic prejudice."

Standard dietaries for a man of 70 kilograms.
(Weights in grams)

	Voit	Rubner
Light work—		
Protein	..	123
Fat	..	46
Carbohydrates	..	377
Calories	..	2,445
Medium work—		
Protein	118	127
Fat	56	52
Carbohydrates	500	509
Calories	3,005	2,868
Hard work—		
Protein	145	165
Fat	100	70
Carbohydrates	500	565
Calories	3,574	3,36,232 [as in original]

The calorie make-up of our village dietaries, compare with these standard dietaries as follows:

Constituent	Per cent. of total calories Voit	Rubner	Karimpur (May)
Protein	15—17	18—20	14—16
Fat	16—25	16—19	6—14
Carbohydrates	65—67	62—71	71—78

According to this, our village diets are high in carbohydrates, while protein, and especially fat, are low. This is what we might expect when cereals are used so extensively, and when proteins come from vegetable rather than animal sources.

Protein—In writing of protein standards for family dietaries Sherman states, "To allow for varying conditions and for individual preferences as well as to provide a liberal margin for safety it is customary to consider that from 10 to 15 per cent of the total calories may be in the form of protein." (33). The daily average of protein in our tables is as follows:

(33) See References.

Protein in dietaries of four Karimpur families

Family	Month	Daily average (grams)	Per cent. of total calories (daily average) in form of protein
Brahman	May	466.8	14
	November	440.7	13
Carpenter	May	297.3	16
	November	364.5	11
Oil-presser	May	325.9	16
	November	231.14	13
Outcaste	May	170.19	16
	November	180.80	13

Although the protein according to figures in the record of food consumed appears to be more than the amount needed, with one exception (the carpenter family in May), it does not exceed the percentage of calories suggested as correct by Sherman (10 to 15 per cent.).

McCay (34) gives the following table of percentage absorption of proteins of the food materials in use in the jail dietaries of the United Provinces.

Food stuff	Absorption of protein
Wheat	67.10
Arhar "dal" (pigeon pea) plus vegetables	80.50
Arhar "dal" (pigeon pea) alone	81.84
Gram "dal" (split gram)	64.20
Barley	57.60
Juar (great millet)	53.00
"Urd"	69.20
"Bajra" (spiked millet)	49.40

From this he concludes: "It cannot be for the welfare of the body that an average of 34 grams of protein daily should remain incapable of absorption, which, while in the bowel, provides a splendid culture medium for the growth of putrefactive micro-organisms." (35).

He comments on the importance of the methods of treatment of foods, especially the split pulses, in relation to their absorption. "Gram dal, for instance,

(34), (35) See References.

is usually given as a morning meal in the form of parched gram, i.e. simply fried or heated until the greater part of the contained moisture is got rid of; no steps whatever are taken to break up the grains so that the digestive juices may have a proper opportunity of carrying out their work satisfactorily. Investigations on the absorption of pea and lentil flour, properly cooked, show that the protein is all taken up except about 8 to 9 per cent. If, however, the pulse is not given in a state of fine division, the loss of protein has been found to rise to 40 per cent." (36).

Not only must the absorption of proteins be considered, but also their ability to meet body needs after absorption. This ability apparently depends upon the amino-acids which the proteins yield on digestion. Therefore, "It seem logical to prefer to serve the needs of the body by providing it with the optimal amount of such proteins as can be utilized very effectively rather than to require it to digest and assimilate an excessive amount of proteins of low value." (37).

A group of Indians are undertaking a study of the pulses which are the chief sources of protein in the Indian diet. Their first study was that of the globulins of the pigeon pea and field pea, both of which are used in our village. They conclude that "Both the globulins compare favourably with casein and contain requisite amounts of arginine, histidine, and lysine. The arginine content of both the globulins is higher than that of casein, being nearly double in the case of the globulin of Pisum arvense field pea. The two globulins are, however, very deficient in both cystine and tryptophane. These legumes are usually taken with cereals and are useful in supplying the essential *diamino* acids especially lysine in which cereal proteins are usually deficient." (38).

Later they studied the values of the lentil (lens esculenta), cow pea (vigna catjang), the aconite bean (the "moth" of our village). They found that all three pulses contain lysine, histidine, arginine, cystine, tyrosine and tryptophane. Their comparison of their utility is: "The analysis of the three globulins shows that the globulin of lens esculenta is characterized by its higher content of lysine and arginine. The net protein values

$$\frac{\text{content of digestible protein} \times \text{biological value}}{100}$$

of the pulse calculated from the metabolism data are given in the following table:

Pulse	Total Protein (N × 6.25)	Net Protein value
	Per cent.	Per cent.
Lens Esculenta	28.74	12.86
Vigna catjang	26.52	11.05
Phaseolus aconitifolius	27.09	9.04

(36), (37), (38) See References.

At a 10 per cent. level of intake, the proteins of lens esculenta are highly digestible while those of vigna catjang have a high biological value. Phaseolus aconitifolius is poor in both respects." (39).

It is interesting that the aconite bean ("moth") is very little cultivated by our people. They seem to keep it especially for invalids. Lentils are not common in Karimpur.

McCollum and Simmonds contribute experimental evidence on the possibility of vegetarian diets. They state that in their own earlier experiments and those of Slonaker, vegetarian rats "grew to about half the size and lived half as long as did their fellows receiving animal food." (40).

Later, McCollum and Simmonds found that it was necessary to introduce a very large quantity of leafy vegetables into a diet of seeds and legumes, to induce normal growth and development in omniverous animals. Their most satisfactory combination was, "maize 50, alfalfa leaf (dry) 30, and cooked dried peas 20 per cent. The ingredients were ground together so that these proportions were eaten." (41). Their conclusion is: "It is possible that better mixtures of vegetable foods may be found, but these results show definitely that for the omniverous type of animal, whose digestive tract is small, the consumption of sufficient volumes of leafy foods is impossible." (42).

In regard to the effect of a purely vegetarian diet on men they conclude that, "It is possible to make a fairly satisfactory diet of foods derived entirely from vegetable sources, but it is not easy to do so. It would be difficult for man to eat enough leafy foods to enable him to succeed with a strictly vegetarian diet. Such a diet will generally be low in protein." (43).

Our village people supply the necessary protein from the pulses, or legumes. But a more successful diet has been worked out by the Sikhs and others further North, who occasionally eat meat and eggs, and drink large quantities of milk. The success of the Sikhs is in agreement with the suggestion of McCollum and Simmonds. "When one adheres to such a regimen (vegetarianism) the addition of small amounts of meat will be valuable, and eggs, because of their relative richness in vitamins A and B, will often be a more effective supplement. The same may be said of glandular organs." (44). The close of their discussion is interesting from the point of view of our study.

"Many of the people of China and Japan, because of poverty and overcrowding, can afford only small additions of fish, poultry, eggs, or the flesh of mammals to a diet which consists in great measure of vegetable foods. From an early age the children are schooled to eat large amounts of leafy vegetables. Many weeds are eagerly sought after and trees are stripped of their buds in spring to supplement the supply of spinach, cabbage, and other leafy foods." This might almost have been written of our village. It explains the gathering of wild potherbs and the picking of tops of growing plants as well as the eagerness for buds of plum trees.

(39), (40), (41), (42), (43), (44) See References.

Repeated studies have shown that whereas proteins of plant origin may be adequate for full-grown adults, they do not contain all of the amino acids which must be supplied in the building of strong new bodies, and they are therefore not sufficient for growing children. Children should have the protein of milk or milk products, and other animal proteins if possible.

Calcium and phosphorus—Calcium is the most consistent deficiency shown in our comparison of food needs and food consumption. Calcium in the Brahman family is higher in May than in November. They also had milk during May, and not in November. The oil-presser's calcium rises in November along with the addition of two quarts of buttermilk. In the outcaste family there was a similar increase in calcium with the addition of milk.

Our American dentist in India told us that there was a deficiency of calcium in the milk of Indian cows and buffaloes. He prescribed calcium lactate for our children.

My own experience with teeth and pregnancy has caused me to wonder about calcium in Indian foods. There seems to be no lack of phosphorus. I lost two teeth with each new baby. I realized that it must be that my own body calcium was being used to build the baby's bones and drank quantities of milk to renew the supply. If I, with over a quart of milk a day, suffered from calcium shortage or from improper balance of calcium and phosphorus, the condition of village mothers should be worse. And it is. They suffer greatly with their teeth, and of course have never heard of a dentist.

The cereals are secondary sources of calcium, and become important because of the large quantities in which they are eaten. Raw cane sugar also supplies calcium. And it is the only sugar used in the village. In the absence of definite information I have credited *ghee* with an amount of calcium equivalent to that in butter. But I feel sure that it should be less, as some calcium must be lost with the protein which, separated during long cooking, is strained off.

Phosphorus—It is apparent from our figures that we need not be concerned over a shortage of phosphorus in the diet. The cereals and pulses supply it in generous amounts. But we cannot count on American figures to represent accurately the amount of phosphorus in Indian foods. This is one element which is known to vary in different soils.

Our chief interest in phosphorus is in its relation to calcium in the work of bone-building. The village children apparently get plenty of phosphorus, but their calcium is deficient. This increases the importance of sunshine in maintaining a proper balance between the two. This will be discussed further, in connexion with Vitamin D.

Iron—Of the several surprises which came to me from the comparison of the needs and the foods consumed in the village, the greatest was the iron. I expected to find a striking deficiency here. But deficiency appears only in the carpenter family in November, and the outcaste family in both May and November.

Here again, as with phosphorus, the cereals and legumes are important. "Most of these grains (wheat, barley, millet, maize, rice) are eaten whole; they are not subjected to any milling or refining process before use. The outer layers of the grain and embryo, containing valuable dietary constituents, are thus consumed with the endosperm." (45).

This use of the whole grains is important to people who are near the margin of deficiency of minerals, especially iron. The green foods which supply our people with iron are not prominent either in May or November. The oil-presser managed to get some spinach. Potatoes appear, in the Brahman family in November, and raw sugar appears in every family as a source of iron.

But with iron as with other food elements, we cannot base our conclusions as to its utilization on figures representing its appearance in the foods we eat.

"Recent research shows that the percentage of iron contained in a food is not by itself an adequate measure of the value of that food in meeting the iron requirement of the body." (46).

Experiments with different food combinations reported by Sherman have shown different degrees of assimilation of the iron. He points out that further research will be necessary before these variations in iron values from equivalent iron contents can be explained.

Vitamins—The prevalence of eye infections prepares one for a deficiency of Vitamin A. And a study of the foods eaten shows that a deficiency exists. We do not know just how much A is lost in the heating of milk, its churning and standing and final long heating in the preparation of *ghi.* According to McCollum and Simmonds A is readily oxidized at higher temperatures, but is relatively stable under conditions generally maintained in the cooking of foods. (47). However, the supply of A from milk is not what we might count on in an American village where butter is used in place of *ghi.* Mustard oil is not an efficient source of A, as A is absent or present in but traces in fats or oils of vegetable origin. Moreover, the percentage of total fat in the diet is low.

Carrots are a possible source of Vitamin A. A report on a study of carrots made by Bills and McDonald showed that the most highly coloured carrots contained 9.6 mg. carotene per 100 g. White varieties contained only about one-eightieth of this amount. (48).

The thin, green leaves of plants have been found to be richer in A than the thicker or whiter leaves. This may help to explain the popularity of the tender tips of leguminous plants.

Vitamin B is supplied by the cereals and pulses which our people eat in abundance. Fortunately it is not harmed in drying and not easily destroyed in cooking. McCarrison demonstrates by experiment the high value of wheat, and the almost equal value of great millet and spiked millet, in Vitamin B as compared with rice. (49). The amount of B which village people get in their cereal flour is greater

(45), (46), (47), (48), (49) See References.

than that of the town dwellers who pride themselves on their thin cakes, made of white flour.

In vitamin B as in A, the leafy vegetables, including mustard greens, make a small contribution. Meat can only be reckoned as a source of vitamins in a few cases.

There is little chance of getting a satisfactory supply of B_2 for the women and children, since the men drink most of the butter-milk. They refuse meat, and the idea of yeast is repulsive to them. Indian mothers see the growth of our children and ask why they grow so much faster and are so much more vigorous than village children. Vitamins may be the answer.

We have talked in terms of vitamin C during the past few years. But long before it was called this, an antiscorbutic value was attributed to foods containing it. As has been mentioned, the tamarind was regarded as an antiscorbutic food, in ancient Sanskrit medicine. McCay in his investigations quotes the rules from the jail code, made before 1911. "1061.—Between the first of April and the first of November when the supply of antiscorbutic vegetables is very indifferent, provision should be made for the daily issuance of an allowance of lime-juice, tamarind pulp, or amchur (dried green mangoes) to each prisoner." (50).

Mangoes are probably our most important available source of C. The following report promises further information on its potency. Several varieties of mango were studied.

"The pulp of the "Alphonso" is stated to be one of the most potent known sources of vitamin C and compares favourably with lemon juice, while "cawaije Patel" is only slightly less active. The 'shundrya' variety is comparatively poor.

"The vitamin A content of the pulp of all three varieties is comparable with that of butter. The "Alphonso" variety was found to be rather better than the other two." (51).

Not knowing what variety of mangoes we have, we hardly know what this study may mean to our village. But it promises further helpful information.

A study of the vitamin C content of Indian food-stuffs made in the nutrition research laboratories, Coonoor, in 1935, adds certain other foods to the list of sources of vitamin C. Among the foods available in our village, which supply vitamin C, they would include ripe gauvas, amaranth leaves, green mango pickle (tender, preserved in salt), green chillies, coriander leaves, cabbage (fresh inner leaves), bitter gourd, cauliflower, spinach (fresh), and turnip. Long standing, or cooking in an open vessel endangers the vitamin C.

Our village babies get less vitamin C than their elders. Many babies have been brought to me who seem similar to those described by McCollum thus: "The baby may become pale, lose its appetite and cease to gain. This condition has been termed 'latent scurvy,' and is more to be feared today than the florid, acute form." (52).

(50), (51), (52) See References.

With the balance between calcium and phosphorus as doubtful as it is in our village, vitamin D becomes especially important. No one in the village buys cod-liver oil, as it is too expensive. Fortunately for our children, they are generously supplied with D through exposure to sunshine. We are not certain of the optimal content in the diet of calcium and phosphorus, but we do know that "when the skin is irradiated with light containing a suitable content of ultra-violet rays, normal calcium and phosphorus metabolism will be maintained, even when the proportions of the bone-forming elements are unfavourable." (53). This refers to unfavourable proportions, but may not apply in case there is actual shortage of calcium or phosphorus.

In surveying the foods eaten by the people of Karimpur, in relation to their needs, we are aware of deficiency, but not any one specific deficiency. We know that the men are not as large, and have not as much resistance to infection as their countrymen, the Sikhs. We know that the women and children are not suffering from any striking illness caused by absence of certain food elements, but they are not as strong as they should be. Figures do not demonstrate many conspicuous faults in the diet. And yet we know that there is not the highest degree of nutrition which might be obtained from the foods available. Rainy Season diets—not analyzed.

*Diet of a Brahman family in Karimpur**

Date	Cereal in bread	Split pulse	Vegetables	Milk, butter-milk	Salt
August, 1927	lb.	lb. oz.	lb. oz.	(Butter-milk) qt.	oz.
13	Wheat . . 14	. .	Gourd . . 5 8	2	. .
14	" . . 7	Field peas 3 6	. .	2	. .
	Barley . . 7				
15	Wheat . . 7	Mung . . 2 13	. .	. .	. .
	Barley . . 1				
16	Wheat . . 14	Pigeon pea 1 6	. .	. .	. .
17	" . . 7	Urd . . 1 6	. .	. . .	. .
18	" . . 7	Urd . . 2 13	Mushrooms 0 12	. .	. .
	Barley . . 7				
19	Wheat . . 14	. .	Egypt arum 2 13	2	16
			Gourd . . 1 6		

*Three women, three men, three children.

(53) See References.

*Diet of a farmer family in Karimpur**

Date	Cereals			Vegetables			Milk butter-milk	Fruit	Salt
August, 1927		lb.	oz.		lb.	oz.	(Butter-milk) qt.	(Dried mango) oz.	oz.
13	Wheat ..	4	4	Gourd ..	1	4	1½	..	..
14	Barley ..	4	4	Mushroom ..	0	12	1½	..	..
15	" ..	4	4	..			1½	12	..
16	" ..	4	4	Mushroom ..	0	12	1½	..	..
17	" ..	4	4	..			1½	..	..
18	" ..	4	4	..			1½	..	..
19	" ..	4	4	Gourd ..	1	4	1½	..	8

*Two men, one woman, one child

Diet of an outcaste family in Karimpur†

Date	Cereal			Split pulse (field pea)		Vegetable			Sweet		Salt	
August, 1927		lb.	oz.	lb.	oz.		lb.	oz.	lb.	oz.	lb.	oz.
13	Wheat flour	6	0	..		Egypt arum	2	0	..		..	
14	Ditto ..	7	0	..		Mushrooms	0	12	..		..	
15	Barley flour Field pea flour Chick pea flour	2 2 2	5 5 5	..		Wild potherb (nari).	1	6	..		..	
16	Wheat flour Barley flour Chick pea flour	2 2 2	5 5 5	1	6	..			..		..	
17	Barley flour Field pea flour Maize flour	2 2 1	12 12 6	..		..			..			
18	Wheat flour Barley flour Chick pea flour	2 2 2	5 5 5	..		Wild potherb (nari).	1	6			..	
19	Wheat flour	7	0	..		Wild potherb (nari).	1	6	1	2	0	12

†Three men, one woman, two children.

Diet of a Muhammadan family in Karimpur (Most of the food for this particular family is begged from Brahman farmers)*

Date	Cereals			Split pulse	Vegetables			Meat	Salt
August, 1927		lb.	oz.	oz.		lb.	oz.	lb.	oz.
13	Wheat	3	8	..	Egypt arum	0	12	..	..
14	„ ..	1	2	..	Wild potherb (nari).	0	12	..	..
	Barley	1	2						
	Chick pea	1	2						
15	Barley	1	10	..	Egypt arum	0	12	..	..
	Peas ..	1	10	..					
16	Wheat	3	8	..	Wild potherb	0	12	..	..
17	„ ..	1	10	Pigeon pea. 5½.	..			..	
	Barley	1	10						
18	„ ..	1	10	..	Egypt arum	0	12	..	..
	Peas ..	1	10						
19	Wheat	3	8	..	..			2	5

*Two men, one woman, one child.

VI—CONCLUSION

RECOMMENDATIONS

Several years ago an English deputy commissioner set out to improve conditions in a whole government district, not far from ours. His faith was great. In the record of his work he writes, "The secret of all success in the villages is propaganda, and the campaign that has been going on for the last seven years has been wonderfully successful."

"Things undreamt of before, things supposed to be utterly opposed to every custom and sentiment, have come to pass easily and naturally, all owing to continuous and intensive propaganda." (54).

If my confidence were as great as his, I would go first to the village elders, and then to the mothers, with the suggestions which follow.

To the elders I would suggest:

(1) Start orange groves, like those in Kaimganj, fifty miles away.

(2) Replace the old mango trees with new ones.

(3) Grow more potatoes.

(4) Learn from the co-operative society in Fatehgarh, forty miles away, how to store potatoes.

(5) Allow the vegetable growers to raise tomatoes.

(6) Advise the vegetable growers to add more leafy vegetables such as cabbage and chard to their crops.

(7) Get information from the Mainpuri Government experiment farm, on how to get a better milk supply. We have made our contribution to this by securing a high grade bull from the provincial government.

(8) Pass a ruling that fruits must not be picked, or knocked off of trees, until they are ripe. Explain to the men and boys that they will get more from the larger ripe fruit.

If I could find mothers willing to forget custom, I would advise them as follows:

(1) Use wheat for the children as far as possible, and keep the millets and barley for festivals and adult visitors.

(2) If there is little wheat, it is better to mix some of it with other cereals rather than use it up and then give the others, such as millets, alone.

(3) Grind all flour finer for the smaller children, and sift it through coarse cloth as you do now, for festival cakes.

(4) Use pigeon pea in preference to other pulses. Use the others occasionally, for variety, preferably "mung" or "urd."

(54) See References.

(5) Do more than split the pulses. Break them up with the light mill. Or better still, soak the pulse for one day and night; spread it out in a shady corner of the courtyard and keep it covered with a damp cloth until it sprouts. The children will like it.

(6) Ask husbands to give the children more of the buttermilk.

(7) Or give each child a glass of the fresh milk each day. Give each one two or three glasses, if possible. This takes for granted that there is a milk animal—as there is in most homes.

(8) On days when there is milk for the children, give them less pulse.

(9) Rather than fry cakes in "ghi" for the children, toast the cakes and spread them with fresh butter.

(10) If the butter used means a shortage of "ghi", mustard oil can replace the "ghi" for most purposes.

(11) Get eggs, if possible, so that each child will have one or two a week, and gradually increase to four or five a week.

(12) Cook potatoes at least four times a week, if possible. They may be combined with other vegetables and cooked as at present.

(13) Use dasheen (Egyptian arum) during the months when potatoes are not in season.

(14) Cook whatever vegetable is in season, along with potatoes or dasheen. Most vegetables require less cooking than potatoes, and can be added later in the cooking process.

(15) Let the children eat raw carrots, potatoes and cucumbers when there is no cholera in the district.

(16) Try drying carrots, by slicing them thin and spreading them in the sun—as mangoes are dried. Use them in vegetable mixtures when gourds and pumpkins are the chief vegetables in season.

(17) Have a green vegetable at the meal when "kachcha" food can be most easily served. The children can gather fresh potherbs in the rainy season and early fall; and fenugreek and the green tops of peas, gram and mustard plants in the late fall and winter. These same leaves can be dried for the spring, and supplemented with fresh radish tops.

(18) Let the children gather and eat each fruit in its season but encourage them to let the fruit ripen, at home in the sun if not on the trees.

(19) When husbands go to the bazar, ask them to bring home oranges in season, or tomatoes, if they are cheaper.

(20) Plan the children's and your own meals something like this:

Morning—Left-over cakes of wheat or mixed flour, or "satua" (parched cereal) ground finer than for the men. Milk or buttermilk with either one. Allow at least 1 pao (1 cup) for each of the children. Fruit, if there is any.

Noon—Fresh cakes of wheat or mixed flour. Vegetables,—potato and one other. Pulse broken up and cooked thoroughly, with mango, fresh or dried, to flavour it. Or sprouted pulse.

Night—Cakes left from noon, with green vegetable cooked in usual way, one cup of milk or buttermilk for each of the children.

(21) Set regular meal hours for the children and yourselves, as for the men. Ask the children to bring home the eatables they collect from the fields and groves, and share them with you at meal time.

(22) Let them play in the sunshine as they do now, with as few clothes as they now wear.

For the mother of a new baby, I would add the following:

(1) Nurse him for two years, if you want to, and if neither you nor he loses weight begin supplementing your milk with goat's or cow's milk, when he is about a year old, so that he will accept it when your milk is insufficient.

(2) Eat the same kinds of food that you prepare for the children but eat more of them and drink milk if you can possibly get it. You are feeding the baby as well as yourself.

(3) If the baby shows no gain in weight, or cries a great deal, start giving him other food, gradually.

(4) Do not feed him whenever he cries, but try to feed him four times each day, when the shadows are at the same place.

(5) When you start giving him other food do it gradually, beginning with boiled goat's milk diluted with water. You can give him some of the rice water which you drink. Put a little partly ground wheat in a small kettle if you have it, and let it stand beside the milk that is simmering. When it has cooked several hours, strain it and give the liquid to him. When he is about a year old, you can give him some of the potato and other vegetable which you cook, before adding the spices. Mash the vegetable with your cooking spoon. Give him some of the liquid from the green leaves which you cook, before adding spices. Let him have a taste of the egg-yolk prepared for one of the older children. As he gets used to it, add more, until he has one yolk each day. When he has plenty of teeth for chewing, give him a piece of toasted bread, hard enough so that he must chew it before swallowing. Be sure that the flour used in his bread is finely ground. If you cannot get tomato or orange or cabbage juice for him, give him some raw potato, scraped off with the bowl of the iron spoon. As he gets older, give him some of the split pulse cooked for the family, but cooked longer, and mashed. Better still, cook some of the sprouted pulse for two or three minutes for him. Cook the milder fruits which the children bring home, sweeten them and give him the juice. Later he can have the pulp. As he grows, increase the milk, to at least half a quart.

This might go on indefinitely, with all of the detailed instructions used in America for new mothers. It may sound inadequate from the Western point of view. But it is so far beyond present practices in our village that it sounds like the chapter in Mr. Brayne's "Remaking of Village India", called "The Dream".

The reasons for most of the foregoing suggestions are obvious. The suggestions to the village elders are explained by what I have already said of present custom and the shortcomings of the local food supply. The elders demand that each proposal will bring them profit, economic or religious. Health has not yet become equally important with these two. Furthermore, the elders must be satisfied that the proposals are worthwhile before anyone else in the village will consider carrying them out. All this demands more tact and resourcefulness than scientific information.

The reasons for the suggestions concerning foods for children are as follows:

Wheat yields more fat and more minerals per 100 calories than the other cereals do. Moreover experiments have shown that the proteins of wheat more successfully supplement those of pulses, or legumes. McCollum and Simmonds in studying vegetable proteins conclude that "There are however, some remarkable instances of effective supplementing between certain cereals and certain legume seeds. Conspicuous among these successful combinations is wheat and pea. . . . Maize and pea, fed in combination parallel to the wheat and pea relation just mentioned, was almost a failure for the nutrition of the rat. Animals confined to this diet, the only fault of which lay in its protein moiety grew slowly and remained stunted. Fertility was very low and the second generation increased very slowly in weight." Of the combinations used in their experiments, only the wheat and the maize combined with peas are like our village diets.

Our village friends tell us that they used to eat more wheat. But since foreign trade has been introduced, the price of wheat has gone up from 40 pounds to the rupee, to 16 pounds to the rupee. As a result, they sell as much wheat as possible, and hoard the money, while living on inferior grains.

The pigeon pea is recommended, as a source of protein, partly because a larger percentage of it is absorbed than of other pulses. This was shown by McCay's work, reported on page 396. Also, the studies of Niyogi and his co-workers have shown the pigeon pea to be a comparatively satisfactory source of protein, when used with cereals (page 397).

However, the net value of the protein of Indian Pulses is shown to be only about 50 per cent. of the total protein content (page 397). This means great waste, and unprofitable expenditure of energy in its digestion and assimilation.

For this reason, milk or buttermilk are proposed to replace a part of the protein now contributed by pulses. A larger percentage of the protein of milk is assimilated than that of pulses, and the amino acid content of milk protein is more complete. At the same time, milk supplies other materials, such as vitamin A, and provides the calcium in which village diets are conspicuously deficient. Because of these qualities of milk, McCollum calls it a "protective food." "Milk and the leafy vegetables are the only foods so constituted as to make good the deficiencies of cereal grains, legume seeds, tubers, roots and muscle meats. For this reason, McCollum proposed that these foods should be designated "protective foods" in order to give them the prominence they deserve." (55).

(55) See References.

A number of experiments have been made, testing the effect of milk on children. The following from New Zealand where life is comparable to that in our village, is of interest to us. It is reported in Nutrition Abstracts and Reviews, Volume II, no. 2. A test group of 93 Maori children (age 5 to 14 years) received fresh milk daily (½ to 1 pint per child) for 13 weeks, during which period records were kept of their height and weight. Children of another school provided a control group. The children in the test group showed twice the increase in height and two and a half times the gain in weight of those in the control group.

A marked decrease in the incidence of scabies and impetigo was noted among the children receiving milk. There also seemed to be an improvement in their mental alertness. (56).

Butter is suggested to replace ghee on the supposition that in the long standing and heating preparatory to the final production of ghee, there is a loss in vitamin A. And the village diet needs a supply of vitamin A badly. This is evidenced by the sore eyes and the corneal ulcers shown us by parents who hope that we can magically restore sight. When the butter is heated and strained, much of the protein is strained out, and some of the minerals undoubtedly go with it. We have no exact information on this. Ghee is such an important item in diets all over India that it will surely receive examination from Indian nutritionists.

Egg yolk is suggested as another possible source of vitamin A combined with fat and iron and protein of high value. But the adoption of eggs is very doubtful among caste Hindus. For this same reason, meat was not suggested as a children's food, in the list above. The prejudice against it is even greater than that against eggs. Moreover, the meat now available comes from old, decrepit animals, and cannot be recommended for children.

Carrots are advised chiefly because of their vitamin A content.

Potatoes are suggested as a substitute for part of the cereal, now consumed in such large quantities. They are a cheap source of carbohydrate, and at the same time bring in certain constituents such as vitamin C, and iron, which cereals provide in lesser amounts, in proportion to calories supplied.

The germinating legume seeds, and green vegetables are easily obtained contributors of vitamin C, along with the mangoes and tamarinds, and certain other fruits. Oranges are within reach, and may come into use gradually. But the introduction of tomatoes, while simpler from the physical standpoint, will depend on influence other than soil, or nutrition.

All of these suggestions are general, and will require special application in individual cases. I have no illusions as to the difficulty of securing their adoption. Back in the village, I shall be bound by the circle of complicating factors. But each suggestion will find reception somewhere. In high caste homes, where eggs are taboo, there is usually an abundance of milk, and great respect for any product of the cow. In outcaste homes where there is little or no milk, chickens are kept. Even in these outcaste homes, a goat is possible, thanks to free grazing.

(56) See References.

The feeding of babies during weaning, as given in the list for new mothers above, is a task which we must undertake seriously. I have gone through the experience with mother after mother, of watching a beautiful baby wither, and feebly slip away. And we have not known what to do. Also, I have gone through the suspense of the feeding of my own babies, and appreciate what it means to have guidance at this time. At present some of our babies gradually starve to death on mother's milk, while their mothers pride themselves on the fact that the babies want no other food. Others find themselves suddenly replaced by a new brother or sister, with coarse cereal cakes and stewed pulse as their new fare. There is a disease called "sukhi" (drying up) among our babies. We could not locate its source, but now I believe that it can be traced to one or perhaps both of the above situations.

There are various methods of treating "sukhi," chiefly with charms and taboos. But I have found no suggestion of its relation to faulty nutrition. It is one phase of feeding which I want most to study on our return to the village.

THE PROBLEM

In approaching this problem of foods in our Hindu village of North India, we should inform ourselves on the following:

(1) The people, their physical condition, including resistance to disease.

(2) The attitude of the people towards suggested practices.

(3) The foods available, locally, with some information on the comparative consumption of each.

(4) The treatment of the foods, including customary practices.

(5) The value of foods used.

We have acquainted ourselves with the first, third and fourth of these through personal observation and inquiry. With the help of medical friends we hope to learn more of the physcal condition of the people when we return among them. Our information on the fifth point comes from various sources, chiefly Western. This field has scarcely been touched in India. The second opens up a whole new field which we hope to investigate.

In trying to solve the problem of how to make the foods of our Hindu village more adequate, further points must be kept in mind.

(1) The foods emphasized should be among those available and those acceptable to at least a part of the community.

(2) The proposals in regard to the treatment of food should be built on familiar practice and should be made with consideration for existing custom and prejudice.

(3) The values of foods recommended, and the treatment of them suggested, should be built upon evidence presented by reputable scientists.

I have kept these points before me in presenting solutions of the problem. With my own knowledge of the foods available, and of current food practices, and with the support of McCarrison, McCollum, Rose, Sherman and others, I know that my suggestions are harmless, at least. With the example of the Sikhs who live not far

from us and who have practically the same food resources as our people, I know that we are striving toward something attainable and worthwhile. The problem has resolved itself to a simple matching of human needs and a comparatively satisfactory food supply. McCarrison has expressed the result very simply in his Primer intended for Indian school children.

"The right kind of food for Indian children and indeed, for children in any country is one made up of the following simple things: (1) any whole cereal grain or mixture of cereal grains; (2) plenty of milk and the products of milk—curds, buttermilk, butter, *ghee;* (3) sprouted pulses; (4) eggs or liver, or meat, or fish occasionally, if religion permits their use; (5) tuber and root vegetables; (6) abundance of green leafy vegetables; and, (7) fruit."

It sounds very simple. And we have satisfied ourselves that it is right.

But the hardest task of all remains. Our village folk are illiterate and their lives are directed by custom, and fear of spirits. We cannot give them the reasons which Science offers for adopting the new food practices recommended here. The propaganda method of the English commissioner did not prove itself lasting after his departure. Then, how are we going to help our people to feel a need for better food to such an extent that they will be ready to improve their food resources, and improve the methods of utilizing those resources? This step carries us from the present study into a whole new field. On our success in exploring this new field, the effectiveness of our solution of the food problem rests. We must carry our information back to our village and translate it into village terms, with the help of educated Indian friends who can interpret for us. They know the world of spirits in which villagers dwell, better than we do.

An illustration of this is one of the many stories told about a gallant Indian woman lawyer who goes into remote sections of the country in connexion with her official duties. Once while visiting a home where her women clients were particularly superstitious, she found them in terror of the threatened visit of the smallpox goddess. The goddess had already brought tragedy to several of their neighbours. They were using all of the charms within their reach to persuade her to pass their house by. The educated Indian woman knew the futility of urging vaccination in this home. She asked the women if the smallpox goddess did not like a sacrifice of blood. They agreed that she did. Then said the educated woman, "I know a spirit charmer who wards off the smallpox goddess by blood sacrifice. Each of you may share in the offering." They had already employed the services of local spirit charmers, and were ready to try another. The educated woman drove to the nearest town and brought the district vaccinator back with her. He was allowed to scratch the arm of every one in the family. They were warned that in a few days the goddess would come, but learning of their blood sacrifice, she would pass on without the usual terrible visit. Women like this, rather than scientists, can help us in the study of present attitudes, and in the task of interpreting in terms of those attitudes. Education is slowly reaching the villages. But until it is much better than at present, we do not want our people

to cast everything of the past aside. In so doing they would lose much of value which experience has taught them.

I should like to close this study, with a suggestion of the future of nutrition in India. In 1928, the following statement was made by the Royal Commission on Agriculture:

"The problems of human nutrition, which have only recently come into prominence are being investigated by Colonel McCarrison who is working under the Research Fund Association at Coonoor. He lays emphasis on malnutrition as a problem facing those engaged in agricultural research. In his inquiries, Colonel McCarrison invokes the aid of the agricultural departments. The problems of human and animal nutrition are likely to assume such importance that we consider it desirable that work on human nutrition and on the nutrition of farm animals should be carried out in the closest co-operation, or, in other words, that there should be team work by workers with a knowledge of different branches of the science of nutrition. Continuity is also essential. The various workers on nutrition problems should be formed into a committee on nutrition which would meet at regular intervals to discuss common questions. This would assure the requisite close touch between different branches of the subject. In view of the importance of the subject, we recommend that a central institute of human nutrition should be established." (57).

Since this report, the important work carried on at Coonoor has continued, under the direction of Sir Robert McCarrison, until his recent retirement. His successor, Dr. W. R. Aykroyd, has a record of thorough scientific research. To this he is rapidly adding an interest in ways of meeting the nutritional needs of poorer families in India. He has already worked out an adequate diet which is low in cost, and available in villages. Meanwhile, further research is being conducted, and applied practically in the All-India Institute of Hygiene and Public Health, Calcutta. There are other centres of useful research, in Calcutta, Bangalore, Bombay, and Allahabad. Indian food-stuffs are being analysed, so that we shall no longer depend upon Western tables. Ordinary diets are being tested, both in laboratories and in boarding institutions.

The most recent move has been the correlaton of these scattered studies. During the last Indian Science Congress, in Indore, in February, 1936, an Indian Nutrition Committee was formed. And still more recently, our new Viceroy revived the above quoted suggestions of the Royal Commission of which he was chairman, at the opening meeting of the new Nutrition Advisory Committee of the Indian Research Fund Association. We look upon this committee as the beginning of active, unified interest in human nutrition in India.

Meanwhile, public interest in this subject has been growing; popular lectures on diet problems now have their place in gatherings to promote public welfare. Leaflets are being prepared like that issued by the Bombay Presidency Baby and Health Week Association on Balanced Diets. Newspapers and magazines now publish

(57) See References.

more articles on nutrition within a month than they did in a year when the Royal Commission first proposed an institute of human nutrition.

All of this is bound to influence the literate townsman. But much more must be done, to reach the illiterate villager and his wife. Perhaps establishing literacy is the first step. To quote from the Viceroy's speech at the opening of the Nutrition Advisory Committee: "I am entirely convinced that, whether we are concerned to advance among the rural population improved agricultural practice or better sanitation and hygiene or better nutrition, we shall find that our best endeavours will achieve little that will endure unless and until literacy is imparted to the women of the countryside. We may bring about some considerable degree of improvement under existing conditions by means of intensive propaganda and close supervision, but in default of female literacy it will be found that whenever supervision is removed there will be a relapse into age-old customs and that, within a few months, nothing will be left of the better living that has been so laboriously inculcated." While literacy is being made possible, we must find ways of presenting better nutrition in terms of a villager's experience. He is suspicious of anything new or strange. If we press upon him, ideas which have not been carefully tested, or ideas which involve drastic change, we shall strengthen his prejudice against what he regards as interference. But he and his wife will gladly accept one simple suggestion at a time, if they understand its benefit and see that this benefit can be attained without additional cost. They are too poor to risk even a pice in experimenting. And while their simple, very practical learning is going on, we can educate their children toward an understanding and appreciation of the purposes and results of Science.

References*

(1) Church, A. H. Food-Grains of India. Chapman and Hall, London, p. 73.
(2) Mainpuri Gazetteer, p. 4.
(3) Moreland, W. H., Indian Civil Service. Agriculture of the United Provinces. Published by Government Central Press, Allahabad.
(4) Mainpuri Gazetteer, p. 3.
(5) Mukerjee, Radhakamal. The Rural Economy of India. Longmans, Green & Co., 1926, p. 31.
(6) Wiser, W. H. Social Institutions of a Hindu village of North India, p. 17.
(7) Moreland, W. H. Agriculture of the United Provinces. Government Central Press, Allahabad, pp. 131–132.
(8) Church, A. H. Food-Grains of India. Chapman and Hall, London, p. 98.
(9) McCay, Major D. Investigations into the Jail Dietaries of the United Provinces. Scientific Memoirs (New Series), No. 48. Superintendent, Government Printing, Calcutta, 1911, p. 21.
(10) Blunt, E. A. H., Indian Civil Service. The Caste System of Northern India. Oxford University Press, Madras, 1931, p. 88.
(11) Bose, Basanta C., M.A., B.L. Hindu Customs in Bengal. The Book Company, Ltd., Calcutta, p. 99.
(12) Jafri, S. N. A., B.A., Bar.-at-Law. The History and Status of Landlords and Tenants in the United Provinces (India). The Pioneer Press, Allahabad, 1931, pp. 215 and 216.
(13) Ghurye, G. S., PH.D. Caste and Race in India. London, Kegan Paul, Trench, Trubner and Co., Ltd., 1932, p. 7.
(14) Blunt, E. A. H., op. cit., p. 89.

*As in the rest of the paper, the citations are given exactly as in the original text.

(15) Translated by Kaccoo Mal Mouncha, Rai Bahadur, in "Hindu Home Life." London Printing Press, Lucknow, p. 30.

(16) Stieglitz, Julius, Ed. Chemistry in Medicine. Chemical Foundation, New York, 1928. Dietary Diseases, by J. M. Gamble, M.D., p. 160.

(17) Annual Report of the Sanitary Commissioner with the Government of India for 1880.

(18) McCay, D., op. cit., p. and 336. [as in original.]

(19) McCay, D., op. cit., p. 135.

(20) McCay, D., op. cit., p. 140.

(21) McCay, D., op. cit., p. 156.

(22) McCay, D., op. cit., p. 126.

(23) McCarrison, R. A Good Diet and a Bad One: An Experimental Contrast. Indian Journal of Medical Research. Vol. XIV, No. 3, January, 1927, p. 647.

(24) McCarrison, R. A Good Diet and a Bad One: An Experimental Contrast. Indian Journal of Medical Research. Vol. LXV, No. 3, January, 1927, pp. 649–654.

(25) A typed copy of this article was sent to me by Colonel McCarrison.

(26) Dietary Scales and Standards for Measuring a Family's Nutritive Needs. Technical Bulletin No. 8, U. S. Department of Agriculture, November, 1927.

(27) Sherman, H. C. Chemistry of Food, Fourth edition, p. 320 ff.

(28) Rose, Vahlteich, Robb and Bloomfield. Journal of Nutrition, Vol. III, November, 1930.

(29) Rose, Mary Swartz. Foundations of Nutrition. MacMillan & Co., 1930, pp. 170 and 183.

(30) Rose, Mary S. Feeding the Family, Third edition. MacMillan & Co., 1929, pp. 118 and 119.

(31) McCay, op. cit., p. 123.

(32) Lusk, Graham. The Elements of the Science of Nutrition, Fourth edition. W. B. Saunders, Philadelphia, 1928, p. 459.

(33) Sherman. Chemistry of Food and Nutrition, Third edition, re-written, 1931. MacMillan & Co., p. 541.

(34) McCay, op. cit., p. 123.

(35) McCay, op. cit., p. 125.

(36) McCay, op. cit., p. 133.

(37) McCollum and Simmonds. Newer Knowledge of Nutrition. MacMillan & Co., New York, 1929, p. 94.

(38) Niyogi, S. B., Narayana, N., Desai, B. G. Studies in Nutritive Value of Indian Vegetable Food-Stuffs, Part I, Nutritive Values of Pigeon pea (Cajanus Indicus) and Field pea (Pisum arvense, Linn.). Indian Journal of Medical Research, 1930-31 XVIII, p. 1217.

(39) Niyogi, S. B., Narayana, N., Desai, B. G. Studies in Nutritive Value of Indian Vegetable Food-Stuffs, Part III, Nutritive Values of Lentil, Lens Esculenta, Moench; cow pea, Vigna Catjang Walp; and Aconite Bean, Phaseolus Aconitifolius, Jacq. By S. P. Niyogi, N. Narayana, B. G. Desai.

(40) McCollum and Simmonds, op. cit.

(41) McCollum and Simmonds, op. cit., p. 149.

(42) McCollum and Simmonds, op. cit., p. 151.

(43) McCollum and Simmonds, op. cit., p. 153.

(44) McCollum and Simmonds, op. cit., p. 153.

(45) McCarrison. Problems of Nutrition in India. Nutrition Abstracts and Reviews, Vol. II, No. 1, p. 1.

(46) Sherman, op. cit., p. 321.

(47) McCollum and Simmonds. On the Story of the Discovery of the Vitamins. Chemistry of Medicine. Edited by J. Stieglitz, Chemical Foundation, New York.

(48) Bills, C. E., and McDonald, F. G. The Carotene Content of Ten Varieties of Carrots, Science, 1932, p. 76, 108.

(49) McCarrison, R. The Nutritive Value of Wheat, Paddy and certain Other Food-Grains. Indian Journal of Medical Research, Vol. XIV, No. 3, January, 1927.

(50) McCay, op. cit., p. 19.

(51) Perry, E. O. V., and Zieva, S. S. Preliminary Report on Vitamin Content of the Mango, Nutrition Abstracts and Reviews, Vol. II, No. 1, 1932, pp. 60, 61.

(52) McCollum and Simmonds, op. cit., p. 169.

(53) McCollum and Simmonds and Stieglitz, op. cit., p. 141.

(54) Brayne, F. L. The Remaking of Village India, London, 1929, p. 64.

(55) McCollum and Simmonds, op. cit., Fourth edition, p. 133.

(56) Turbott, H. B., and Rolland, A. F. The Nutritional Value of Milk. Experimental evidence from Maori school children. N. Z. Medical Journal, 1932, 31, p. 109–111.

(57) Royal Commission on Agriculture in India. Abridged report. Government Central Press, Bombay, 1928, p. 58.

GENERAL INDEX TO VOLUME XLII

New scientific names of plants and the final members of new combinations are printed in bold face type; synonyms and page numbers having reference to figures and plates, in *italics;* and all other matter in ordinary type.

A

Acanthothamnus aphyllus, 285
Acarospora (Pachnolepia) Gwynnii, 144
Adélie Land, lichen flora of, 143
Adlay, 105; chromosome morphology of, 115, *127*, *128*
Alectoria congesta, 143, 145
Allosorus andromedaefolius, 102
Alsodeia glabra, 231
Anaxagorea Allenii, 151; crassipetala, 151; dolichocarpa, 151
Animal products, as a source of food in Karimpur, 309, 344
Annonaceae, Three new, from Panama, 151
Antarctic continent and the subantarctic islands, Lichenological notes on the flora of the, I–IV, 131
Anthoxanthum, 113
Apluda digitata, 106
Argopsis cymosa, 134
Asiatic relatives of maize, Studies on, 103
Aspicilia disjuguenda, 135; lygomma, 135
Aspiciliopsis macrophthalma, 135
Australian National Antarctic Research Expedition, lichens collected by, 131

B

Balansia trinitensis, 136
Blastenia keroplasta, 135
"Blue Adlay", 107, 108, *109;* chromosome morphology of, 115, *127*, *128*
Botanical catalogues of Auguste de St. Hilaire, 153
Brahmans, food habits of, 307, 379, 400
Brazil, botanical collectors in, 153
Briza, 113
Buellia *frigida*, 143, 146; Johnstoni, 146; Mawsoni, 143; subplicata, 135

C

Caloplaca crozetica, 135
Catalogues, botanical, of Auguste de St. Hilaire, 153
Catha benthamii, 244; *monosperma*, 249; *vitiensis*, 291
Catillaria (Eucatillaria) **Rudolphii**, 139
Ceanothus paniculatus, 230
Cedar, Red, see Juniperus virginiana
Celastrus, A revision of the genus, 215
Celastrus, 227; aculeatus, 274; *acuminatus*, 285; *adenophylla*, 285; *alatus*, 285; *alpestris*, 285; angulatus, 239; *annamensis*, 244; *aphyllus*, 285; *apoensis*, 246; *approximata*, 250; *aquifolius*, 285; *articulata* var. *cuneata*, 261, var. *orbiculata*, 260; *articulatus*, 260, var. *pubescens*, 261, var. *papillosus*, 261, var. *punctatus*, 266, var. *stephanotiifolius*, 261; *attenuatus*, 285; *australis*, 236; *axillaris*, 250; *benthamii*, 244; *bilocularis*, 285; *bivalvis*, 285; *boaria*, 285; *bodinieri*, 285; *bullatus*, 240; *buxifolia*, 285; *cantonensis*, 249; caseariifolius, 282; *cavaleriei*, 265, 286; *championii*, 244, 246; *chiapensis*, 282; *chungii*, 286; *ciliidens*, 276; *circumcissus*, 286; *colombianus*, 280; *clemacanthus*, 276; *confertus*, 286; *crassifolia*, 273; *crenatus*, 286; *crenulatus*, 286; *crispulus*, 266; *cuneifolius*, 286; *cunninghamii*, 286, var. *parviflora*, 286; *dependens*, 231; *dilatatus*, 286; discolor, 285; *disperma*, 286; *diversifolia*, 286; *dubia*, 286; *elevativenus*, 267; *emarginatus*, 286; *esquirolianus*, 286; *esquirolii*, 287; *euonymoidea*, 287; *euphlebiphyllus*, 231; *fasciculatus*, 287; *feddei*, 287; *finlaysonianus*, 287; **flagellaris**, **276**; *floribundus*, 287; *fournieri*, 287; *geminiflorus*, 267; *gemmata*, 258; gemmatus, 258; glaucophyllus, 253; *glaucus*, 287; *gracillimus*, 267; grenadensis, 285; *haenkea*, 287; *hamelii*, 287; *heterophyllus*, 287; *heyneana*, 287; hindsii, 249, var. *henryi*, 249; hirsutus, 270; hookeri, 254; *hookeri*, 274; *hypoglaucus*, 257; hypoleucus, 257, f. β. *argutior*, 257, f. α. *genuina*, 257, f. γ. *puberula*, 273; *ilicifolius*, 287; *insularis*, 261; *japonicus*, 287; *jeholensis*, 261; *jodinii*, 287; *kiusianus*, 266; *kouytchensis*, 287; kusanoi, 268; lancifolia, 261; *laotica*, 231; *latifolius*, 239; *leiocarpus*, 267; lenticellatus, 278; *leptopus*, 287; *liebmannii*, 279; *linearis* var. *madagascariensis*, 287;

lineatus, 287; *listeri*, 288; *loeseneri*, 265; *lokchongensis*, 258; *longe-racemosus*, 267; *longipes*, 281; lucida, 291; *lucida*, 288; *lycioides*, 288; *lyi*, 288; *macrocarpus*, 288; madagascariensis, 238; *magellanicus*, 288; *mainsiana*, 279; *mairei*, 288; *malayensis*, 246; *marianensis*, 250; *mauritiana*, 288; *maytenus*, 288; membranifolius, 255; meridensis, 284; *merrillii*, 250; *metzianus*, 230; *mexicanus*, 288; *micrantha*, 288; microcarpus, 285; *mollis*, 288; *monosperma*, 249; monospermoides, 246; monospermus, 244; *montana*, 288; *moya*, 288; *muelleri*, 288; *multiflorus*, 231; *myrtiflorus*, 288; *neglecta*, 272, 288; *nepalensis*, 288; novoguineensis, 234; *nutans*, 229; *oblanceifolia*, 274; *oblongifolius*, 250; *obtusatus*, 288; *obtusifolia*, 288; *octogonus*, 288; *opposita*, 289; *orbiculata* f. *major* 261, f. *microphylla*, 261, var. *aureo-arillata*, 261; orbiculatus, 260; *orbiculatus*, 253, f. *papillosus*, 261, var. *papillosus*, 261, var. *pilosus*, 261, var. *punctatus*, 266; *orixa*, 289; *ovalifolius*, 289; *ovatus*, 289; *oxyphyllus*, 289; *pachyrachis*, 279; *pallidus*, 289; panamensis, 280; paniculatus, 229, var. *andamanica*, 230, var. *Balansae*, 236, ssp. multiflorus, 231, ssp. paniculatus, 229, ssp. serratus, 231, var. *pubescens*, 230; *papuana*, 236; *parviflorus*, 289; *parvifolius*, 289; *pauciflora*, 289; *pentagyna*, 289; *polybotrys*, 231; *pringlei*, 281; *pubescens*, 230; punctatus, 266; *punctatus*, 261, var. *microphyllus*, 267; *punctulatus*, 266; *quadrangulatus*, 289; racemosus, 279, var. trinitensis, 285; *racemulosus*, 249; repandus, 285; reticulatus, 285; *retusa*, 289; *rhombifolius*, 289; richardi, 289, γ. *latifolius*, 289, δ. *cochlearifolius*, 289, ε. *elaeodendroides*, 289; richii, 237; *rigida*, 289; *robustus*, 289; rosthornianus, 265; *rothiana*, 229; *rothianus*, 290; *royleanus*, 290; *rufa*, 290; *rugosus*, 253; *salicifolia*, 290; scandens, 240; *scandens*, 266; *seguini*, 290; *semiarillata*, 290; *sepiarius*, 290; *serrulatus*, 290; *siltepecanus*, 282; *spicatus*, 290; *spiciformis*, 256, var. *laevis*, 256; *spinifolius*, 290; *spinosus*, 290; *stephanotiifolius*, 261; *striatus*, 266, 290; *strigillosus*, 261; *stylosa*, 254, 265, var. *Loeseneri*, 254; stylosus, 272, ssp. stylosus, 272, ssp. glaber, 273; *suaveolens*, 290; subspicatus, 236; *tatarinowii*, 260; *tetramerus*, 290; *tristis*, 290; *uncinatus*, 290; vanioti, 256; *variabilis*, 290; *venulosus*, 249; *versicolor*, 261; *verticillata*, 290; *verticillatus*, 290; *vitiensis*, 291; vulcanicolus, 282; *wallichianus*, 291; *wallichii*, 291; *wightianus*, 291; *yunnanensis*, 291; *zeylanica*, 291

Cenomyce phyllophora, 134; *sarmentosa*, 140

Cereals used in North India, 329

Chailletia gelonioides, 285

Chionachne, 103, 106, 108, chromosome morphology of, 114, *125*, *130*; biaurita, 106; Hubbardiana, 106; Koenigii, 106, 107, 111, *112*, 113, chromosome morphology of, 117, *125*, *130*; Massii, 106; semiteres, 106

Chlorocyphella, 136; subtropica, 136

Chromosome morphology of Coix, Polytoca and Chionachne, 114

Chromosome numbers: in Celastrus, 225; in Coix, 113, in Selaginella, 11

Cladia aggregata, 140

Cladonia floriformis, 140; Johnstoni, 134; Mawsoni, 140; phyllophora, 134; sarmentosa, 140

Coenogonium subtorulosum, 137

Coix: cytological study of, 107, materials used, 107, methods, 113; history of, 103; nomenclature in the genus, 104

Coix, 103; agrestis, 104; aquatica, 104, 108, 113; arundinacea, 104, 106; barbata, 106; chinensis, 104; from Cuttack, India, 108; crypsoides, 106; exaltata, 104; gigantea, 104, 109, 110, 116, *125*, *128*, *129*, f. aquatica, 104, 114; heteroclita, 106; Koenigii, 106; Lachryma, 104, var. stenocarpa, 113; Lacryma-Jobi, 104, 108, f. agrestis, 104, var. agrestis, 104, f. aquatica, 104, var. aquatica, 104, var. gigantea, 104, var. major, 104, f. aquatica, 104, f. "mayuen", 104, var. "Mayuen," 104, 113, var. Ma-yuen (1), 116, *124*, var. Ma-yuen (2), 116, *124–128*, var. minor, 104, f. monilifer, 103, var. monilifer, 104, f. palustris, 104, var. palustris, 104, f. stenocarpa, 104, var. stenocarpa, 104, var. typica "Blue Adlay," 105, 108, 115, *124*, *126–128*; lingulata, 104; Ma-yuen, 104; ouwehandii, 104; palustris, 104; pendula, 104; poilanei, 104, 108, *109*, 113, 114, 116, *124–128*; puellarum, 104; stenocarpa, 104; tubulosa, 104; from western Ghats, India, 109

Collemopsidium **pyrenuloides**, 133

Colubrina ferruginosa, 289

Coyx tubulosa, 104

Cuvier's account of St. Hilaire's travels, 154

Cyathorhachis Wallichiana, 106

Cyphella aeruginascens, 136

Cytology of Coix and its relatives, 115

D

"Dal Roti" in India, 333
Dale, Ernest E., Norton H. Nickerson and: Tassel modifications in Zea Mays, 195
Deuterolichenes, 136
Diosma serrata, 231
Doryopteris, a new species of, from Surinam, 213
Doryopteris, 213; collina, 214; **conformis**, 213, *214*; lomariacea, 213; pedata var. multipartita, 214; sagittifolia, 214; varians, 214
Dreuzy's appendix to St. Hilaire's "Voyage à Rio Grande do Sol," 157
Dwyer, John D.: The botanical catalogues of Auguste de St. Hilaire, 153

E

Ear of Zea Mays, morphology of, 195
Ecological factors in relation to distribution of Juniperus, 187
Elaeodendron glaucum, 287
Eleonurus candidus var. bisetosus, 167
Embelia esquirolii, 258
Ephelidium, 136; **heardense**, 136
Ephelis, 136; trinitensis, 136
Erythrospermum hypoleucum, 257
Euonymus altus, 290; cuneifolius, 286; *euphlebiphyllus*, 231; thunbergianus, 285
Euonymoides, 227; *scandens*, 240

F

Ferns, See Pellaea and Selaginella
Festival dishes of North India, 346
Flueggia serrata, 249
Food: Coix as, 105; of North India, 303; diet of Brahmans, 307, 379, of other castes, 381, 401
Foods of a Hindu Village in North India, 303
Forage plants, 103
Frequency distribution of three species of Celastrus, *232*
Fries, Robert E.: Three new Annonaceae from Panama, 151
Fruits eaten in India, 316, 341

G

Gasparrinia Harrissoni, 146; macquariensis, 142
Geographical distribution of Coix, relationship between chromosome number and, 120
"Ghi" as food in North India, 368
Glade in Missouri Botanical Garden Arboretum, 173, *190*; species list with frequencies for under story of, 178
Gouania corylifolia, 290
Gramineae, 103
Gray Summit, Mo., history of land usage at, 173
Greens used as food in India, 341
Grewia feddei, 287; henryi, 287
Guatteria inuncta var. **caudata**, 152
Gymnosporia acuminata, 289; crenata, 286; diversifolia, 286; emarginata, 286; heyneana, 287; montana, 286, 288, 289; neglecta, 285, 288; *neglecta*, 272; ovata, 289; rothiana, 290; royleana, 290; rufa, 290; trigyna, 288; variabilis, 290; vitiensis, 286, 291; wallichiana, 286, 289, 291

H

Hall, Marion Trufant: Comparison of Juniper populations on an Ozark Glade and Old Fields, 171, Appendix, 192
Heard Island: Additions to the Lichen flora of, 131; views of, *149*
Heppia antarctica, 144
Heredity, Zea Mays as a tool in study of, 195
Hindu village in North India, foods of a, 303
Hou, Ding: A revision of the genus Celastrus, 215
Hybridization in Celastrus, 225

I

Ilex crenata, 285; *cuneifolia*, 287; macrocarpa, 290; purpurea, 285; scandens, 286; suaveolens, 290
India: Coix from, 108, 109; Foods of a Hindu village in, 303; food plants of, 103
Inflorescence of Zea Mays: staminate, see Tassel; pistillate, see Ear
Inflorescences of Celastrus, 219; diagrams of, *220*, *221*
Introgression in Juniperus, 171, 186
Iodina rhombifolia, 289

J

Job's Tears, see Coix
Juniper populations on an Ozark glade and old fields, Comparison of, 171
Juniperus, 171; Ashei, 171, variation in, 181, *182*; horizontalis, 171; virginiana, 171, variation in, 181, 183, Eastern race, 171, Northern race, 171, 186, Ozark race, 171, 186; virginiana var. crebra, 171, 186, var. typica, 171; virginiana × J. Ashei, 186
Juniperus virginiana and J. Ashei, variation patterns in, 181, *182*, *184*, *185*

K

Karimpur, India, foods of, 303
Kramer, Karl U., and Rolla M. Tryon, Jr.: A new species of Doryopteris from Surinam, 213
Kurrima sp., 289
Kuttlingeria crozetica, 135

L

Leaves of Juniperus, variations in, 181, *182*, *184*, *185*
Lecanora *chrysoleuca* v. *melanophthalma* f. *exsulans*, 145; *dichroa*, 134; *disjunguenda*, 135; *exsulans*, 145; griseomarginata, 145; *perrugosa*, 140; *versicolor*, 137
Lecidea assentiens, 134; Auberti, 134; Harrissoni, 144; *lygomma*, 135; subassentiens, 134; subglobulata, 139; *subplicata*, 135
Lichen aggregatus, 140
Lichenological notes on the flora of the Antarctic continent and the subantarctic islands, I–IV, 131
Lichina antarctica, 132
Lopadium perpallidum, 136; Deightoni, 136
Lycopodium *bryoides*, 40, 67; carinatum, 82; *ciliatum*, 77; *Dregei*, 57; *laxum*, 82; *rupestre*, 64; *struthioloides*, 81, 82

M

Macquarie Island, additions to the Lichen flora of, 137
Mac Robertson Land, additions to the flora of, 143
Maize: in North India, 329; Studies on Asiatic relatives of, 103; Tassel modifications in, 195
Mangoes in North India, 316
Maytenus bilocularis, 285; boaria, 285, 288, 290; buxifolius, 289; cochlearifolius, 289; confertus, 286; cunninghamii, 286; dispermus, 286; elaeodendroides, 289; fournieri, 287; lineatus, 287; macrocarpus, 288; magellanicus, 288; *meridensis*, 284; orbicularis, 286, 288, 289; ovata, 289; quadrangulatus, 289; *racemosus*, 279; retusa, 286, 289; truncatus, 287; verticillatus, 290; *williamsii*, 282
Meiosis in Coix and related genera, 118
Menegazzia circumsorediata, 142
Microglaena kerguelena, 132
Microthelia macquariensis, 137
Microtropis bivalvis, 285
Missouri Botanical Garden Arboretum, 172: Junipers at Cedar Hill, 175; The Glade, 173; The Old Field, 174; species list with frequencies for understory of Glade and Old Field, 178
Morphology of tassel of Zea Mays, 195
Moya spinosa, 288
Mutants of tassel of Zea Mays: descriptions of, 199; key to, 196; measurements of morphological features, 197; spikelet pairs on, 211; Branched Silkless, *pl. 28*; Club, *pl. 27*; male-sterile, *pl. 27*; Ramosa 1 and Ramosa 2, *pl. 29*; Standard, *pl. 22*; Tassel-seed 1 and Tassel-seed 2, *pl. 23*; Tassel-seed 3 and Tassel-seed 4, *pl. 24*; Tassel-seed 5 and Tassel-seed 6, *pl. 25*; Tassel-seed 7 and Tassel-seed 8, *pl. 26*; Vestigial glume, *pl. 28*
Myrsine semiserrata, 286, 290

N

Neuropogon aeromelanus v. *inactivus* f. *scabridulus*, 143; *insularis*, 135; *trachycarpus*, 135
Nickerson, Norton H., and Ernest E. Dale: Tassel modifications in Zea Mays, 195
Nirodi, Nalini: Studies on Asiatic relatives of maize, 103
Nostoc, sp., 146
Nutrition practices in a Hindu village of North India, 356

O

Old fields in Missouri Botanical Garden Arboretum, 174, *190*, *191*; distribution of Juniper seedlings in, 180; variations of junipers in, 180, 181; species list with frequencies for understory of, 178
Orixa japonica, 286, 287, 289
Ozark glade and old fields, Comparison of Juniper populations on, 171

P

Pannaria dichroa, 134; *glaucella*, 132
Parmelia Johnstoni, 145; *pubescens* v. *congesta*, 145; sublugubris, 142; tenuirima, 142; turgidula, 142
Pellaea, A new, from South Africa, 101
Pellaea andromedaefolia, 102; intermedia, 102; ovata, 102; myrtillifolia, 101; rufa, 101, *102*
Peltigera Lairdi, 138
People of India, 304
Perrottetia alpestris, 285
Pertusaria tyloplaca, 140
Phyllanthus sp., 290
Pittosporum floribundum, 288, 290
Placodium bicolor, 135
Placopsis bicolor, 135; perrugosa, 140
Pleurostylia cochinchinensis, 289, 291
Polytoca, 103, 108; barbata, 113; bracteata, 106; cyathopoda, 106; digitata, 106; javanica, 106; macrophylla, 106, 107,

110, *111*, 113, chromosome morphology of, 117, *126*, *129*, 130; Massii, 106; semiteres, 106; Wallichiana, 106
Populations, Juniper, comparisons of, on an Ozark glade and old fields, 171; Appendix, 192
Prema parvilimba, 291
Preservation of food in North India, 323
Protoplastenia citrina, 145
Prunus myrtifolia, 288
Pseudocyphellaria glabra, 138
Psoroma versicolor, 137
Pulses, use of, as food in North India, 333, 337

R

Ramalina geniculata, 142
Red Cedar, see Juniperus virginiana
Rhamnus crenatus, 286, 287; esquirolii, 288; napalensis, 290; racemosus, 287
Rhizocarpon Johnstoni, 134; kerguelense, 134; Mawsoni, 134
Rinodina aspicilina, 136; frigida, 143, 146
Rudolph, Emanuel D., Carroll W. Dodge and: Lichenological notes on the flora of the Antarctic continent and the subantarctic islands, I–IV, 131

S

Sabia parviflora var. nitidissima, 287; yunnanensis, 288
St. Hilaire, Auguste de, The botanical catalogues of, 153: numbers of collections listed under specific families, *159*; numerical sequences of, 158; page of Catalogue C², *168*; page from list of collection numbers, *170*; role of catalogues in taxanomic monographs, 163; Weddell's key to, 161, *169*
Saurauja vaniota, 256
Schoepfia flexuosa, 287
Sclerachne, 103; cyathopoda, 106; punctata, 113
Scutia commersonii, 291; *paniculata*, 230
Selaginella rupestris and its allies, 1
Selaginella, 16; *acanthonota*, 26; *amazonica*, 34; *Arachavaletae*, 34; *arenaria*, 26; arenicola, 23, ssp. acanthonota, 26, *94*, ssp. arenicola, 26, *94*, ssp. Riddellii, 24; arizonica, 78, *99*; Arsenei, 41, *95*; *Aschenbornii*, 77; asprella, 75, *98*; Balansae, 27, *94*; Bigelovii, 22, *94*; *Bolanderi*, 49; *Bourgeaui*, 64; *bryoides*, 40; *caffrorum*, 53, *96*; *capensis*, 53; carinata, 50, *96*; *Chrismarii*, 20, var. *Karwinskyana*, 20, var. *Neeana*, 20; cinerascens, 40, *95*; *columbiana*, 67; *Coryi*, 28; deflexa, 16; densa, 66, var. densa, 66, *97*, *98*, var. scopulorum, *97*, var. Standleyi, 71, *97*; denticulata, 11; Dregei, 57, *96*, var. *Bachmanniana*, 57, var. *Hildebrandtiana*, 57, var. *Petersiana*, 57, var. *pretoriensis*, 57, var. *Rehmanniana*, 57, var. *Welwitschiana*, 57; echinata, 54, *96*; *Engelmannii*, 68, eremophila, 80, *99*; extensa, 47, *95*; *Fendleri*, 62; *floridana*, 26; *funiformis*, 26; gracillima, 17; *grisea*, 57; Hansenii, 49, *96*; *Haydenii*, 76; helvetica, 11; *Hintonii*, 37; *humifusa*, 26; indica, 52, *96*; Landii, 81, *99*; lepidophylla, 8; leucobryoides, 74, *98*; *longipila*, 52, 68; macrathera, 41, *95*; *Mildei*, 34; *montanensis*, 43; *montevideensis*, 34; mutica, 44, var. limitanea, 46, var. mutica, 46, *95*, var. *texana*, 46; *muticola* × *rupincola*, 21, × neomexicana, 21; nivea, 55, *96*; njamnjamensis, 52, *96*; *oregana*, 61, *97*; Parishii, 80, *99*; *pauciciliata*, 34; peruviana, 77, *99*, var. *Dombeyana*, 77; *Phillipsiana*, 40; *porrecta*, 37; *Preissiana*, 17; proxima, 56, *96*; *pumila*, 17; pygmaea, 17; *Quartiniana*, 53; *Riddellii*, 24; *Rosendahlii*, 43; rupestris, 64, *97*, f. *amazonica*, 34, f. *amurensis*, 71, f. *Bolanderi*, 49; *Bourgeaui*, 64, f. *brasiliensis*, 34, f. *caffrorum*, 53, f. *Dregei*, 57, f. *Engelmannii*, 70; *Hansenii*, 49, f. *Haydenii*, 70, f. *indica*, 52, f. *longipila*, 68, f. *manchuriensis*, 71, f. *montanensis*, 43, f. *peruviana*, 77, f. *Schmidtii*, 71, f. *sibirica*, 71, f. *Wallacei*, 43, f. *Wrightii*, 48, ssp. *Balansae*, 27, var. *acanthonota*, 26, var. *Balansae*, 27, var. *Bolanderi*, 49, var. *borealis*, 81, var. *brasiliensis*, 34, var. *brevipila*, 81, var. *columbiana*, 43, var. *densa*, 70, var. *Fendleri*, 62, var. *Hansenii*, 49, var. *incurva*, 53, f. *abyssinica*, 53, f. *angolensis*, 53, f. *capensis*, 53, var. *longipila*, 81, subvar. *glaucina*, 81, subvar. *viridis*, 81, var. *mexicana*, 47, 77, var. *montanensis*, 43, var. *peruviana*, 77, var. *recurva*, 57, f. *Dregeana*, 57, f. *Welwitschiana*, 57, var. *rupincola*, 20, var. *Sartorii*, 37, var. *shakotanensis*, 43, var. *Sherwoodii*, 29, var. *tortipila*, 29, var. *tropica*, 82, var. *Wallacei*, 43; *rupincola*, 20, *94*; Sartorii, 36, *95*, var. *oregonensis*, 36, var. *venezuelensis*, 36; *Schmidtii*, 71, var. *Krauseorum*, 71; *scopulorum*, 67; selaginoides, 16; Sellowii, 34, *95*; shakotanensis, 43, *95*; *Sheldonii*, 77; *Sherwoodii*, 29; sibirica, 71, *98*; *spinulosa*, 11; *Standleyi*, 71; Steyermarkii, 49, *95*; *struthioloides*, 82; tortipila, 29, *94*; uliginosa, 17; Underwoodii, 62, *97*,

var. *dolichotricha*, 62; utahensis, 74, *98*; Vardei, 61, *97*; *viridissima*, 28, *94*; Wallacei, 43, *95*, f. *columbiana*, 43; Watsonii, 72, *98*; var. *mutica*, 46; Weatherbiana, 28, *94*; Wightii, 39, var. Phillipsiana, 40, var. *vetusta*, 39, var. Wightii, 39; Wrightii, 48, *95*; *Wrightii*, 48
Semarilla, 227
Sempervirentes, 242
Simmondsia californica, 288
Siphulastrum cladinoides, 133
South Africa, A new Pellaea from, 101
Spices used in cooking food in North India, 319
Sporopodium, 136
Stachygynandrum rupestre, 94
Steinera glaucella, 132; Werthii, 132
Stereocaulon argodes, 140; *Argus*, 140; *cymosum*, 134; pulvinare, 140; submollescens, 140
Stricta glabra, 138
Surinam, A new species of Doryopteris from, 213

T

Tassel modifications in Zea Mays, 195
Tassels of Zea Mays: morphology of, 195; certain mutants of, 196, *pls. 22–29*, relationships between, and normal tassels, 198
Taxonomic monographs, role of St. Hilaire's catalogues in, 163
Thamnolecania macquariensis, 141
Thelidium heardense, 131; praevalescens, 131
Tichothecium, 133
Tomatoes, use of, in North India, 309
Trichilia jodinii, 287
Trilobachne, 103
Trinidad, Coix "Blue Adlay" from, 108
Tripterygium wilfordii, 286
Tryon, Alice F.: A new Pellaea from South Africa, 101
Tryon, Rolla M., Jr.: Selaginella rupestris and its allies, 1; Karl U. Kramer and: A new species of Doryopteris from Surinam, 213

U

Umbilicaria *antarctica* v. *subvirginis*, 144; Hunteri, 143; spongiosa v. subvirginis, 144; subcerebriformis, 144
United Provinces of India, food of, 304
Unonopsis costaricensis, 152; guatterioides, 152; obovata, 152; panamensis, 151; Pittieri, 152; Schippii, 152
Urceolaria macrophthalma, 135
Ureceolina kergueliensis, 134
Urostachys carinatus, 82
Usnea antarctica, 143; arida v. muscicola, 142; contexta, 142; *dasypogoides*, 142; insularis, 135; pustulata, 143; scabridula, 143; Taylori, 135; torulosa, 142; trachycarpa, 135; xanthopoga, 142

V

Variation in Juniperus at the Garden Arboretum, 181
Vegetables grown in North India, 315, 336
Verrucaria kerguelena, 132; *prevalescens*, 131

W

Weddell's key to catalogues of St. Hilaire, 161; portion of page from, *169*
Wiser, Charlotte Viall: Foods of a Hindu Village in North India, 303
Wimmeria mexicana, 288
Wheat: grown in India, 330; bread from, 333

X

Xanthopyrenia heardensis, 132
Xanthoria Mawsoni, 143, 146

Z

Zea Mays: Tassel modifications in, 195; tassel mutants, illustrations of, *pls. 22–29*, key to, 196

MISSOURI BOTANICAL GARDEN

STAFF

Emeritus Director
GEORGE T. MOORE

Director
EDGAR ANDERSON

Assistant Director
HUGH C. CUTLER

CARROLL W. DODGE,
Mycologist

ROBERT E. WOODSON, JR.,
Senior Taxonomist

HENRY N. ANDREWS,
Paleobotanist

ROLLA M. TRYON,
Assistant Curator of the Herbarium

HUGH C. CUTLER,
Curator Museum of Economic Plants

GEORGE B. VAN SCHAACK,
Acting Curator of Herbarium

JULIAN A. STEYERMARK,
Honorary Research Associate

FREDERICK G. MEYER,
Dendrologist

ALICE F. TRYON,
Research Associate

JOHN D. DWYER,
Research Associate

NELL C. HORNER,
Librarian and Editor of Publications

BOARD OF TRUSTEES

President
JOHN S. LEHMANN

Vice-President
DANIEL K. CATLIN

Second Vice-President
EUGENE PETTUS

LEICESTER B. FAUST
DUDLEY FRENCH
HENRY HITCHCOCK
RICHARD J. LOCKWOOD
HENRY B. PFLAGER
A. WESSEL SHAPLEIGH
ROBERT BROOKINGS SMITH

EX-OFFICIO MEMBERS

ARTHUR C. LICHTENBERGER,
Bishop of the Diocese of Missouri

JAMES F. MORRELL,
President of the Board of Education of St. Louis

STRATFORD LEE MORTON,
President of the Academy of Science of St. Louis

ETHAN A. H. SHEPLEY,
Chancellor of Washington University

RAYMOND R. TUCKER,
Mayor of the City of St. Louis

HUGH C. CUTLER, *Secretary*